Report

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Wales Catchment-Sensitive Farming Demonstration Project

Evaluation Project

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Summary

There was a high level of adoption of the Wales Catchment-sensitive Farming Demonstration Project, which supported farmers in their attempts to reduce the risk of water pollution from their farms. This was attributed to the high ratio of good catchment officers to farmers. A large majority of farmers reported that, with hindsight, they had made a good decision joining the scheme. Routine water monitoring is insufficient to show any direct impacts of such schemes, while dedicated monitoring schemes are expensive. The costs of further reducing pollution risk on these types of farm may cost up £70,000 per farm.

Cymraeg

Roedd yna lefel uchel o fabwysiadu'r Cynllun Arddangos Ffermio sy'n Sensitif i Ddalgylch ymysg ffermwyr. Cynllun ydoedd i gefnogi ffermwyr gymryd camau i leihau'r risg o lygredd dŵr o'u ffermydd. Roedd hyn wedi'i seilio ar gymhareb uchel o swyddogion dalgylch da i ffermwyr. Wrth edrych yn ôl, fe adroddodd nifer o ffermwyr eu bod wedi gwneud penderfyniad da yn ymuno efo'r cynllun. Mae profi dŵr rheolaidd yn fodd aneffeithiol i ddangos effeithiau uniongyrchol cynlluniau o'r fath, tra mae cynlluniau monitro uniongyrchol a dwys yn gostus. Gall y gost o leihau risg llygredd ymhellach ar y mathau hyn o ffermydd fod hyd at £70,000 i bob fferm.

EXECUTIVE SUMMARY

Background

In 2005 the Welsh Assembly Government (WAG) established a catchment-sensitive farming demonstration project in three catchments within Wales (Llafar and Twrch in Gwynedd and Deepford Brook in Pembrokeshire). The purpose of the demonstration project was to raise awareness of catchment-sensitive farming issues, to trial various practical measures, and to evaluate their effectiveness in improving the quality of water bodies within the project catchments.

As part of this initiative, WAG commissioned an evaluation of the CSF pilot project. The evaluation project, reported here, sought to ascertain the effectiveness of the demonstration project in changing farmer attitudes, influencing farming practices and improving the quality of local water bodies. It also sought to evaluate the effectiveness of the different measures applied within the pilot project and to make recommendations on the design of future targeted measures for agriculture within Wales.

The specific aims of this evaluation project are:

(i) Evaluate the demonstration project in terms of its effectiveness in mobilising the farming community to adopt catchment-sensitive farming measures; tackle potential pollution hazards and improve the quality of water bodies within the two project areas.
(ii) Evaluate attitudes within the farming community towards catchment-sensitive farming at the beginning and end of the project.
(iii) Assess which measures the farming community adopted and which they did not, together with an analysis of the reasons given.
(iv) Identify costs to farm businesses of measures carried out
(v) Identify extent of pollution problems remaining after the project and the potential cost to the farming community of tackling them.
(vi) Identify measures that need to be included in future CSF schemes to effectively tackle pollution

This report presents the findings of the evaluation project in 6 chapters. Chapter 1 is an Introduction. Chapter 2 reports the results of a survey of farmers' attitudes undertaken at the beginning and end of the demonstration project. Chapter 3 presents an analysis of stakeholder opinions about the demonstration project. Chapter 4 offers a critique of the soil and water monitoring protocols within the demonstration project. Chapter 5 is an economic analysis of the demonstration project. Chapter 6 offers overall comments and makes some recommendations that may be borne in mind when designing and running future catchment schemes. The main results from these chapters are summarised below.

Farmer perceptions and attitudes

Farmers in three catchments (Llafar, Twrch and Deepford) were surveyed in 2006, at the start of the catchment-sensitive farming demonstration project; and in 2008, at its end. As part of these surveys farmers were asked about their farms and their perceptions of the CSF scheme. In addition a series of qualitative and quantitative questions sought information on their attitudes to water quality in particular, and the environment in general. A control survey undertaken in 2006, 2007 and 2008 asked similar questions to farmers outside the CSF pilot scheme areas, and also of the general public. The responses to the control survey helped interpret the results of the farmer survey.

Results from both the qualitative and the quantitative analysis suggest that taking part in the CSF project had changed farmers' attitudes in several ways. They had become more wildlife-

aware and more positive about the benefits of legislation and cooperation. They had also become more aware of their potential for improving the environment.

Although some farmers raised some criticisms about the design and administration of the scheme, their overall opinions of the CSF scheme were very positive. This is evidenced by the large proportion of the farmers surveyed in 2008 who stated that, with hindsight, they wee glad that they entered the scheme, and would be likely to engage in similar initiatives in the future.

Stakeholder assessment

Twenty-one stakeholders from public and private organisations were interviewed in the summer of 2008, using a semi-structured interview technique. The main topics covered in the discussions included the aims and objectives of the demonstration project; communication and dissemination of the project; project implementation; project deliverables and project monitoring.

There was a general feeling of satisfaction with the scope of the demonstration project and the scale of its operation. Communication with farmers in the demonstration catchments was felt to have been good, but there were some suggestions as to how communications with other farmers in Wales could have been enhanced. Stakeholders were generally content with the design and operation of the demonstration project, however a range of small criticisms were made, and several stakeholders felt that improvements could be made in the future implementations of any catchment based schemes. Several stakeholders had expected more intensive monitoring that could have offered solid evidence as to the success or otherwise of the demonstration scheme. There was disappointment that this had not proved possible.

Water quality data evaluation

A review of relevant information on water quality in the catchments, river flows, non-agricultural nutrient sources and rainfall data was undertaken. It concluded that the relative paucity of suitable baseline and post-intervention monitoring data from the demonstration project catchments meant that a detailed analysis of the water-quality response to CSF interventions could not be undertaken.

Water quality monitoring data for analysing changes due to CSF interventions would need to use much more sensitive analytical methods than are currently used by the Environment Agency as part of their standard monitoring programme. In addition there would be a need to reduce or eliminate the large numbers of ‘less than’ values, (i.e. values reported as being below the detection limit of the analytical method used) that are typically recorded in standard water quality databases. It was noted that event sampling does not provide a complete picture of flows or water quality and that automated equipment which can offer near-continuous sampling may be more appropriate in catchments where diffuse pollution is the main problem.

Other point sources in the catchments may also contribute to water quality issues. Discharges from private sewage treatment systems (PSTSs) such as septic tank systems and cess pits may affect water quality. In the Llafar and Twrch catchments there were 19 PSTSs at a distance of 50 m or less from a watercourse.
Plantation forestry also carries a risk of sediment pollution at the initial stages of ground preparation and road building; and release of nitrate and potassium into watercourses at forest harvesting. These nutrient pulses last 2-5 years for nitrate, and 1-2 years for potassium.

Sewage treatment works (STWs) are monitored by the Environment Agency, and their nutrient output is strongly affected by dilution; during low flow they become more important contributors to the nutrient content in the streams. Without flow data for the streams and the effluent it is not possible to assess the contribution of the STWs to the total flux of nutrients

reaching the lake. Any future scheme aiming to take an holistic approach to reducing water quality would need to consider the potential impact of forestry, sewage treatment works and PSTS as well as agriculture.

The demonstration project included field-level analysis of nutrients. However, there have been developments in the chemistry of nutrient analysis, and it could be advantageous to future CSF projects to incorporate an environmental soil-P test alongside, or instead of, the conventional agronomic Olsen-P test. This would provide more appropriate information for water quality risk assessment and modelling; although the data would be less familiar to farmers and agricultural advisors.

Given the high costs of sampling and chemical analysis, it is important that future water-quality monitoring programmes be highly focused and designed to identify changes in response to CSF interventions. The pilot study experience has shown that catchments are highly individual, and it is neither possible nor desirable to be prescriptive in the design of monitoring programmes. It is recommended that CSF projects and the supporting monitoring must have well-defined water quality objectives; so that limited monitoring resources can be effectively allocated.

Economics

The average cost of implementing measures within the catchment-sensitive demonstration project was £19,624. On average farmers contributed £8,689 towards these costs, and the grant constituted 55.7% of the full cost of the works.

Twenty-one farms which had joined the CSF scheme were visited by a team of staff to undertake a 'pollution audit' during the summer of 2007. The purpose of this visit was to identify all possible sources of pollution risk on the farm and to make recommendations as to the most practicable measure of reducing the risk of pollution to 'as close to zero as possible'. There was considerable difference between those measures that the individual farms adopted under CSF and what the pollution audit actually recommended could be adopted in order to minimise pollution risk. The pollution audit regularly recommended higher rates of implementation of measures such as roofing works, dirty water storage fencing out of watercourses and concrete works than were observed in the CSF. However, the opposite was true for waste stores, which were adopted at a higher rate under CSF than were recommended by the audit.

The total cost of implementing the measures recommended by the auditors for the 21 farms in the survey was £2.53million, an average of £120,653 per farm. However there was considerable difference between farm costs in the north and south, with the greater proportion of the total cost attributed to the dairy farms sampled in the south. Average costs per farms were £76,920 in the north but were 2.7 times larger at £208,120 in the south.
If the CSF project were applied to all farms in Wales > 5 ha then the total cost would be £454 million. Raising the cut off point to 10 ha minimum size reduces costs to £380 million, while only funding CSF on farms > 20 ha reduces the total costs to £300 million.
If such a large investment were made in rural Wales, then there would be knock-on effects within the rural economy, e.g. to suppliers of inputs. Using appropriate multiplier coefficients, the total impact of investing £454 million on farms under 5 ha would be in the order of £640 million, with the construction industry receiving the largest share of the extra activity. Smaller investments produce proportionately smaller impacts in the wider economy.
Decision-makers face difficult decisions when evaluating the costs and benefits of any such investment. No attempt was made within the project to measure the wider or social benefits that may occur due to the enhanced water quality resulting from the investments made in CSF. However, data from other studies which have made these estimates suggest that the public do perceive benefits in projects that enhance water quality. While there is a range of location specific benefit estimates, many of these suggest a willingness-to-pay of around £20 per person to be typical, with some studies suggesting a willingness to pay up to £67 / household. If the benefits of CSF accrue only to the population of Wales then in order to

have benefits greater than the costs of implementation individual WTPs would need to be at least £61 for any scheme applied to farms >20 ha. If the scheme were applied to more farms than this, then the required break-even WTP would increase. If the benefits accrued to a wider population of Wales, say all tourists and visitors then again the break-even WTP would decrease appropriately.

Comments and Recommendations

A series of comments and recommendations are offered. When recommendations are made here, this does not mean that they did not occur as part of the CSF pilot scheme. Rather these recommendations summarise best practice. Recommendations are summarised below under five headings:

Start-up and initial stages

1. Recommendation: When announcing a new scheme it is necessary to use a diversity of communication methods including the local press, local organizations, and key informants in the community.

2. Recommendation: In the early phases of a scheme ensure that local connections are made, hold local meetings and seek to develop a good personal relationship between project staff and farmers.

3. Recommendation: Ensure consistent and accurate information is given to farmers from the very beginning of the project. Early misperceptions may delay or prevent later adoption.

4. Recommendation: Farmer motivation to join CSF-type schemes can be enhanced by showing them long term data pertaining to the water quality problem.

5. Recommendation: When describing the project to farmers, ensure that a full list of different advantages is presented.

6. Recommendation: Try to process the applications of the first few individuals extremely quickly as this will offer substantial benefits in terms of good public image. If it is not possible to achieve this due to administrative constraints, then devise a system that actively manages the expectations of farmers, and communicates the timescale for dealing with their application.

7. Recommendation: It may be best to clearly state the reasons that a particular area was selected for inclusion in the scheme, and to publish these in relevant communication materials.

8. Recommendation: Ensure that project officers are enabled to make contact with farmers in order to try and recruit them onto the scheme.

Communication with farmers and other stakeholders

9. Recommendation: Maintain a high level of sensitivity to cultural and linguistic differences across Wales, and wherever possible, strive to offer communication in the most appropriate language.

10. Recommendation: The use of regular newsletters is a valuable communication tool with farmers and other stakeholders, although these different audiences may need different newsletters.

12. Recommendation: Try to use the experience of pilot projects to inform farmers and stakeholders from outside the catchment.

13. Recommendation: Maintain pilot catchments and demonstration farms in Wales, even if similar works are on-going in England; as they are important factors in developing knowledge and experience among stakeholders.

14. Recommendation: Develop a series of demonstration farms in a catchment, each of which can be used to demonstrate best practice in at least one activity. Used together, such a series of farms can demonstrate best practice across a wide range of systems and situations.

Operation of the scheme

15. Recommendation: Given that the measures associated with CSF reduce pollution risk to a greater degree than is expected by both legal standards and cross-compliance, and do not offer direct financial return to farmers a grant rate of >50% seems to be the minimum to encourage adoption. Given the success of CSF, if there is a real need to reduce pollution risk in a particular area, a grant rate of 60% can be justified; and if the works really had no impact on the overall well-being of the farmer then perhaps grants of 100% would be philosophically acceptable.

16. Recommendation: Project officers should receive training that would enable them to visit a farm and rank measures in order of the impact that they would have on pollution risk.

17. Recommendation: It may be best simply to brand all staff as 'project staff' rather than potentially confuse farmers by sending staff from many different organisations to their farms.

18. Recommendation: Consider publishing figures about the percentage of the total project budget that will be spent on administration, evaluation and operations.

19. Recommendation: The capital works options of any scheme could be discussed with relevant planning authorities prior to the beginning of the scheme. It may be possible to develop indicative guidelines to assist project staff and farmers in developing plans for future works. It may also be useful to involve local planning officers in meetings and open days with farmers.

20. Recommendation: Consider issues related to the availability of contractors in an area, and the potential issues of their rising costs as the project proceeds.

Water quality monitoring and assessment

21. Recommendation: Carefully define the purpose of any monitoring to be undertaken as part of CSF; and seek to develop robust and cost-efficient means of delivering that monitoring scheme.

22. Recommendation: Future CSF initiatives should pay close attention to the design of the water quality monitoring programme, to ensure that adequate pre-treatment baseline data are collected; using methods with appropriate detection limits for the type of water body under consideration.

23. Recommendation Future CSF initiatives should pay adequate attention to the provision of appropriate rainfall and flow data for the target catchments.

24. Recommendation: It would be seem wise to consider the contribution from PSTSs when planning future CSF projects, and it may be worthwhile mapping the location and condition of the PSTSs within the target catchments.

25. Recommendation: Future CSF initiatives should consider the use of analyses such as the DESPRAL soil test or estimates of EPC_0.

Project evaluation

26. Recommendation: Plan the evaluation from the outset of the project, but ensure that some level of evaluation can continue for an appropriate time after the project end date.

27. Recommendation: Try and maintain some method of compensating farmers who give up time to participate in surveys.

Overall comments and evaluation

This project, which sought to provide support for capital improvements on farm, was innovative and daring. It tackled a real problem of under-investment on farms and has helped farmers reduce the risk of pollution.

The project was well received by farmers. Although there was some initial concern, the opinions of many farmers changed during the course of the project; becoming much more positive about the scheme in general and its overall aims. The allocation of dedicated project staff and the development of personal relations with the farmers was a major contributory factor in its success.

Inevitably, due to the source of funding there were some constraints on the project. It is very difficult to bring about change in a catchment over two years, and to simultaneously measure and monitor the effects of that change on the environment. If similar projects were to be completed elsewhere, it would be beneficial to fund specific monitoring activities of environmental outputs. These should include good baseline data and continue beyond the end of the project. Only if such baseline data are available can the economic efficiency of the project be measured.

When allocating budgets in projects like this, it is tempting to offer as much money as possible to the final beneficiaries (here, the farmers); and to minimize administrative and management costs. However, farmers do not behave like financially rational automata when considering the adoption of voluntary schemes like this. Rather, the 'softer' social aspects of adoption are very important in determining take-up: self esteem; status and role in the community; feelings of stewardship; desire to reflect a positive image of farmers and farming. It is therefore essential that sufficient consideration and resources are allocated to activities that enhance adoption (i.e. in addition to the standard financial incentives). By enhancing adoption the overall social cost-benefit ratio can be maximised.

CONTENTS

CHAPTER 1. INTRODUCTION

Background to the study

After undertaking a consultation on Catchment-Sensitive Farming (CSF) in 2005 the Welsh Assembly Government (WAG) sought to develop further its catchment-sensitive farming initiative. As part of this initiative WAG established a demonstration project in three catchments within Wales (Llafar and Twrch in Gwynedd and Deepford Brook in Pembrokeshire). The purpose of these demonstration projects was to raise awareness of catchment-sensitive farming issues, to trial various practical measures and evaluate their effectiveness in improving the quality of water bodies within the project catchments. The aim is to learn lessons pertinent to the design and delivery of future targeted measures elsewhere within Wales.

As part of the initiative WAG commissioned an evaluation of the CSF pilot projects. The evaluation project, reported here, sought to evaluate the effectiveness of the demonstration project in changing farmer attitudes, changing farming practices and improving the quality of local water bodies. It also sought to evaluate the effectiveness of the different measures applied within the pilot project and to make recommendations on the design of future targeted measures for agriculture within Wales.

Further details on the physical and hydrological characteristics of the three catchments can be found in the report of a related study undertaken by ExCal which attempted to model alternative scenarios to reduce pollution in the catchments.

Description of the Catchment-sensitive Farming pilot project

The pilot project ran for approximately two years, from 1 October 2005 to 31 December 2007. It was open to applicants with qualifying levels of skills and experience, running viable farm businesses within the pilot catchments. Farms straddling the boundaries of the catchments were only permitted to enter land and buildings into the scheme that were actually situated within the catchment; to a minimum of 10 hectares (unless smaller areas could be demonstrated to offer tangible benefits for water quality).

Assistance was provided to tackle diffuse pollution through improved fertiliser and manure management, combating soil erosion, implementing sensitive supplementary feeding, fencing watercourses, and construction and repairs designed to control run-off from buildings and yards. This assistance was offered in two main forms:

Capital grants of up to 60 % on a range of works designed to combat water pollution. On farmland these included fencing (of stream and river banks); water supply infrastructure such

as troughs and piping; hard surfacing for feeding areas, stock tracks, gateways and water troughs; stream bridges, culverts and piping; and other stream-bank works. In yards, supported works included new concrete yarding and repairs / improvements to old yard surfaces; gutters, downspouts and other rainwater infrastructure including drains to clean water soakaways; roofing or repairing roofs over dirty yards and manure stores; dirty water drainage and storage infrastructure; some slurry / manure store / silage store works, and sheep dipping infrastructure including dip flooring, drainage and holding yards.

Farm nutrient planning, helping to match the timing and amount of manure and fertiliser application to crop requirements and growth. Farmers were offered three services under the CSF pilot study:

(i) Free soil sampling and laboratory testing including analyses for lime, phosphate and potash on all land receiving regular amounts of manure and/or artificial fertiliser.

(ii) Free fertiliser consultation based on a new computerised planning system (Planet). This included the preparation of a farm nutrient management plan taking into account specific crop needs, soil pH (acidity/alkalinity), existing nutrient reserves and the amount of plant nutrients applied via organic manure.

(iii) A free consultation on the nutrient content of manure using the Department for the Environment, Food and Rural Affairs (DEFRA) recommendations as a guide to nutrient availability, adjusting farm inorganic fertiliser applications accordingly.

Additional payments were offered for participating in farm interviews with consultants; and for maintaining farm diaries; accurately recording the timing and amount of bagged fertiliser used, manure applications and stock movements on land within the catchment; and covering a whole growing season from 1 March to 31 October.

Project operations on farms

Each catchment had an appointed Catchment Officer who acted as the main point of contact for the farmers, and who also arranged soil sampling, discussed fertiliser planning and capital works with farmers over a period of at least three farm visits. Farm interviews were conducted separately, to assess farmers' views on catchment-sensitive farming, the progress and conduct of the pilot project, and what changes need to be made in implementing future schemes.

Once farmers had registered their interest in the project, the Catchment Officer made a first farm visit, including a walk of the farm, to identify opportunities for improvement; recording general farm details and existing nutrient management commitments (for example under Farm Assurance schemes). The second farm visit, two to three weeks later, included

recording cropping, stocking, fertiliser practice and manure management information. At this visit soil samples were taken from each field that received fertiliser, for nutrient and pH analysis. The Catchment officer also carried out a field inspection to record details of potential capital works under the CSF project, which were discussed with the farmer and subsequently developed into specifications and planning consent applications. By the third farm visit, soil analysis results were available and had been drafted into a nutrient management plan. At this stage, any capital works for yards and fields amenable to CSF funding were agreed (in principle); nutrient management was discussed with the farmer, and he/she was invited to submit an application to WAG. Formal offers of funding were made subject to a signed contract with the farmer, after which agreed capital expenditure could begin on the farm. At the end of the growing season a fourth farm visit was made in order to review fertiliser use, inspect the farm diary and assess progress on any capital works. Farmers not interested in capital works funding were still able to take part in other elements of the project.

Aims of the evaluation

The specific aims of this evaluation project are:

(i) Evaluate the demonstration project in terms of its effectiveness in mobilising the farming community to adopt catchment-sensitive farming measures; tackle potential pollution hazards and improve the quality of water bodies within the two project areas.

(ii) Evaluate attitudes within the farming community towards catchment-sensitive farming at the beginning and end of the project.

(iii) Assess which measures the farming community adopted and which they did not, together with an analysis of the reasons given.

Structure of the report

This report is presented in 6 chapters:

Chapter 2 reports the results of a survey of farmers undertaken at the beginning and end of the demonstration project. This details farmer perceptions towards different elements of the CSF scheme and also towards wider aspects of the water environment. It includes a statistical analysis of the changes in farmer attitudes that have occurred over the course of the project.

Chapter 3 presents an analysis of stakeholder opinions about the demonstration project. Here, the stakeholders were primarily staff of the Welsh Assembly Government and other public bodies; although some landowners were also included in the analysis.

Chapter 4 offers a critique of the soil and water monitoring protocols within the demonstration project.

Chapter 5 is an economic analysis of the demonstration project, which includes estimates of the costs associated with making farms ‘pollution risk zero’. Data on the regional and social benefits of the scheme are also presented.

Chapter 6 offers overall comments and makes some recommendations that may be borne in mind when designing and running future catchment schemes.

The Appendices include considerable useful information on the study, including textual reports from farmer interviews.

CHAPTER 2. WHAT THE FARMERS FELT ABOUT THE PILOT SCHEME AND HOW IT AFFECTED THEIR BUSINESS AND ATTITUDES.

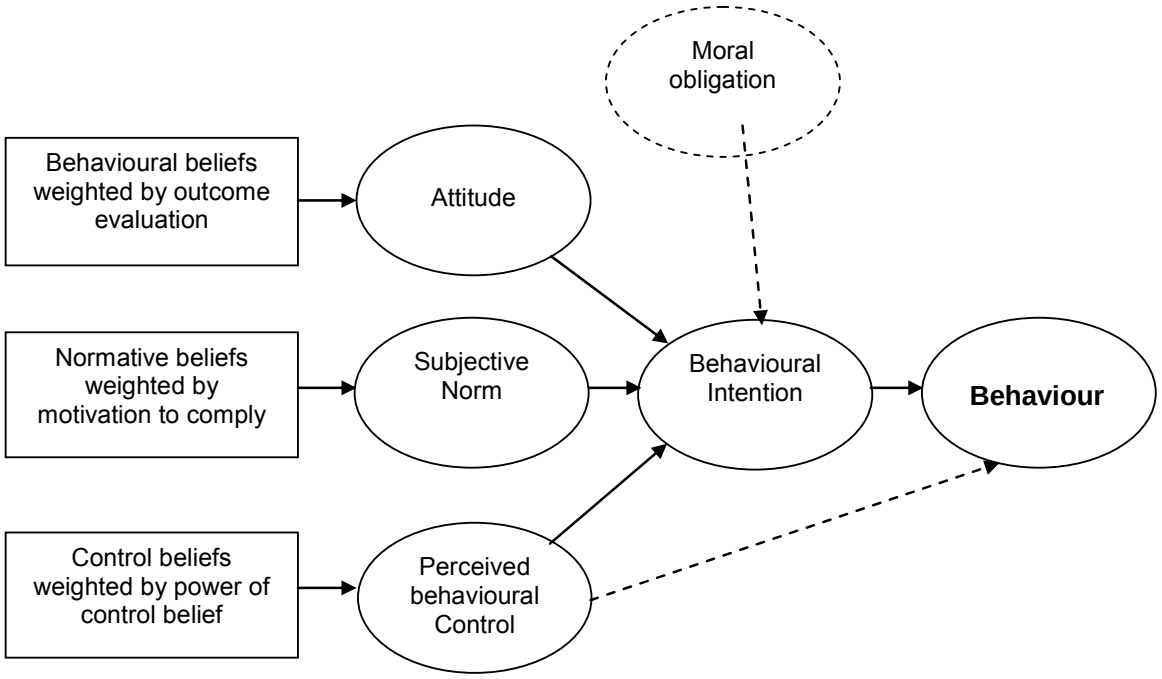
Understanding the importance of farmer attitudes

One of the key aims of the evaluation project was to evaluate attitudes towards catchment-sensitive farming within the farming community, at the beginning and end of the project. The measurement of farmer attitudes has received considerable attention in recent years (Austin *et al.* 1998 a,b; Austin *et al.* 2005, Beedell & Rehman 2000, Carr & Tait 1991, Dutton *et al.*2008, Edwards-Jones 2006, Willock *et al.* 1999a,b; Wilson 1997). One of the reasons for this relates to the realisation amongst agricultural scientists and policy makers that attitudes are fundamental in determining farmer behaviour. This relation between attitudes and behaviour has been known by psychologists for some time, and is implicit in the theory of planned behaviour (Azjen 1981). This is a leading psychological theory of decision-making, which suggests that attitudes interact with other aspects of personality to influence behaviour (Figure 2.1). This model has been tested for farmers, and work by Austin *et al.* (1998 a, b) clearly showed that it can explain significant amounts (about 30%) of the variation in the adoption of environmentally-related behaviour.

If, as theory suggests, attitudes are important in determining behaviour, then we may assume that by altering attitudes we may subsequently affect behaviour. This assumption lies at the heart of many public health campaigns; which seek to alter attitudes to a particular behaviour, in the hope that behaviour will change. A good example of this type of process relates to both successful 'drink-driving' campaigns and the original 'clunk, click every trip' campaign which sought to encourage the wearing of seat belts. In both of these cases the 'attitude changing' campaign was also accompanied by a changed law. However, this may not always be the case; and sometimes campaigns to change attitudes are reinforced by accompanying financial incentives (e.g. taxes on cigarettes as a disincentive to reduce smoking) and occasionally by no formal policy incentive at all (e.g. the '5 a day' campaign for better nutrition).

While there may well be a link between behaviour and attitudes in some situations, the purpose of applying this thinking to environmental policy is unclear. If Government wanted to change farmer behaviour it could do so by passing legislation, which it could then enforce vigorously. In this way there would be no need to change farmer attitudes, as the desired behaviour would come about through legislative means. However, such an approach has its problems. Firstly, monitoring any such legislation in an agricultural context is difficult.

Figure 2.1. The theory of planned behaviour (Ajzen 1981)



Secondly, there is a general belief, which remains unproven, that farmers who really support a policy will engage more energetically with that policy; and thereby offer more benefits. Finally, there is the issue of sustainability. It could be argued that by forcing farmers to engage with a policy for some time their attitudes will change; if that policy changes or disappears these new attitudes will reinforce the behaviours encouraged by the policy; ensuring that they are continued past the lifetime of the policy. Until recently this latter theory has remained untested in any field related to environment and resource management, however recent work suggests that this process may indeed occur (Gelcich *et al.* 2008).

So while much work on farmer attitudes has followed the accepted psychological theory of planned behaviour which assumes attitudes influence behaviour, newer work does suggest that attitudes may well change in response to 'forced' engagement with a policy (i.e. behaviour). While measuring farmer attitudes to various aspects of catchment-sensitive farming will offer insights into how the programme can be improved prior to any national 'roll out', it can also help us gauge the likely level of environmental behaviours farmers will adopt in the future.

Against this background the evaluation project sought to understand farmer attitudes towards water quality in general and the CSF scheme in particular. The evaluation combined quantitative and qualitative measures of attitudes and perceptions which were collected via interviews with farmers in the relevant catchments in 2006 and 2008.

Methods

Defining and measuring attitudes

Definitions

In academic terms, attitudes are positive or negative views of an 'attitude object'; a person, behaviour or event. In this study we assume that the overarching 'attitude object' is 'the catchment-sensitive farming scheme'. However, this large 'attitude object' can be disaggregated into its constituent parts, such as objectives, payment schemes, staff, impact on business; and attitudes to each of these constituent parts can be assessed separately.

Measurement

Attitudes are typically measured by asking a respondent (here, the farmer) to indicate his/her level of agreement or disagreement with a statement (the so-called Likert scale). The statement is designed to be specifically associated with one of the attitude objects of concern. So for example the following question many be posed;

"To what extent do you agree or disagree with following statement? Please indicate your answer on the scale of 1 (strongly disagree) to 5 (strongly agree) by circling the most appropriate answer.

'Buffer strips impinge on the practical management of my farm'

1	2	3	4	5
Strongly agree	Agree	Neutral	Disagree	Strongly disagree

Respondents answer a number of such questions (normally between 20 and 70) depending on the complexity of the situation. Among these questions would be several questions, each differently phrased, relating to the same attitude object. These may serve both as a check on the validity of the questionnaire itself, and also on the respondents' conscientiousness when answering the questions.

Because of the nature of the questions, it is possible to engage in quantitative analyses of the results; which can range in complexity from straightforward to the complex (see Austin *et al*. 1998 a,b and Austin *et al*. 2005 for examples). Individuals' responses to attitude questions can then also be related to other aspects of the farmer's socio-demographics and his business. So as a result of asking 100 farmers a series of attitudinal questions, it is possible to calculate the overall attitude of the sample to particular attitude objects; and to explore how

attitudes vary with other variables like farm type, farm size or level of education of the farmers. In this project there is a need to calculate attitudes early and later in the project. This can be achieved by using the same questions on both occasions and then analysing the results for any differences.

However, the situation is complicated as the cause of any measured attitudinal change in farmers is unknown and may not necessarily relate to the CSF scheme. For example, consider the hypothetical situation where the attitudes of farmers in one catchment were measured at two separate times, but between the two times two major things had happened: first, all the farmers had joined a catchment-sensitive farming scheme and also there had been a major water pollution event in an adjacent catchment where people had died. In this case either or both of these events might have influenced any change in the farmers' attitudes. In order to control for any such occurrence it is necessary to undertake a survey of a control group over the same timescale as the treatment group (i.e. those farmers in the CSF scheme). Then at the end of the project, rather than ask 'How have the attitudes of the catchment-sensitive farmers changed in an absolute sense?' it becomes possible to ask 'How have the attitudes of the catchment-sensitive farmers changed relative to those of the control group?'. The use of a control group in this way increases the confidence that any changes observed in the treatment group (i.e. those participating in the catchment-sensitive farming programme) are actually due to project participation and not to any other events.

The farmer survey

All farmers within the three catchments entered into the Catchment-Sensitive Farming Scheme were surveyed at the beginning of the scheme in spring 2006; and again in summer 2008. Farmers' names and addresses were supplied by the Welsh Assembly Government. Farmers were initially sent a letter explaining the project and the desire to undertake a survey. Farmers were subsequently contacted by telephone in order to confirm their participation and arrange a time and date for the interview. Farmers were sent the questionnaire before the interview time; interviews were face-to-face and took place in the farmhouse. All the written material was available in both English and Welsh, and the interviews themselves where conducted in the farmers' language of choice. Each interview took between 30 and 60 minutes to complete, and the farmer received £25 as a recompense for the disruption the interview caused them.

The survey instrument (questionnaire) had four sections. The first section sought information on physical and financial aspects of the farm and farm structure. In the 2006 survey, the second section explored the reasons why the farmer might or might not join the CSF scheme.

The third section sought open-ended responses from farmers, on a range of topics related to the structure of the scheme and the maintenance of water quality in general. The final section presented 46 Likert-type statements intended to assess the attitudes of the farmers. These questions were five-point questions with points representing 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree'.

Surveying the public as a control

The purpose of the control survey was to gauge the attitudes of the wider public (including farmers from outside the target catchments); and to see if these attitudes changed over the time of the project. Thus if external event(s) had a major impact on general attitudes towards water quality over the project period, these would be detected in the control survey; thereby enabling suitable analysis and interpretation of the farmer survey.

The control survey was undertaken at the Royal Welsh Agricultural Show during 2006, 2007 and 2008. The interviews were conducted face-to-face by a team of interviewers. The interview team was bilingual, and the surveys conducted in the language chosen by respondents. Respondents were approached in one of five stands on the showground: Bangor University, Farming and Wildlife Advisory Group (FWAG), Farmers Union of Wales (FUW), National Farmers Union (NFU) and Country Landowners and Business Association (CLBA).

A short survey instrument (questionnaire) was used which has two major sections (see Appendix 2). The first section requested socio-demographic information from respondents, while the second included 21 Likert-type statements selected from the 46 that had been used in the farmers' survey. The statements chosen for the control survey were the most general statements and did not include any scheme- or location-specific information.

Statistical analysis

Comparative analysis of attitudes between the public and farmers' samples was based on the 21 Likert statements which were identical in the farmers' surveys and the public questionnaires used at the Royal Welsh Show. The remainder of the questions in farmers' surveys informed us about other aspects of the farmers' attitude to CSF, such as staff ability and project management.

First-order factor analysis

(i) All Likert scores for the 21 statements that were identical for all respondents (public and farmer samples) were subjected to factor analysis in SPSS for Windows (2006) with pair-wise exclusion of missing values (unanswered statements). Factor extraction used principal components and 25 iterations, and the correlation matrix was examined for all factors with Eigenvalues > 1.

(ii) The factors were rotated using Promax rotation, to generate understandable groups of statements. Names were assigned to the resulting five factors, based on the statements associated with them.

Multivariate analysis of first-order factor scores

(i) Individual first-order factor scores were analysed using Principal Components Analysis in Pc-Ord (McCune and Mefford 1999).

(ii) A second matrix was generated using respondents' categorical data such as farm types and sizes, CSF options, demographics, position, rurality.

(iii) These data were used to investigate significant groupings in the factor scores, by Multi-response Permutation Procedures (MRPP) analysis in Pc-Ord. For each significant grouping variable, means and confidence intervals for each of the factors were calculated and compared.

Results

A general description of the physical nature of the farm types in the three catchments in presented in Appendix 3. This also includes socio-demographic data on the farmers who participated in the survey.

Throughout this section direct quotes from farmers are used to exemplify some of the points made in the text. These are shown in italics. A full record of the comments made by farmers in the 2006 and 2008 survey is given in Appendix 4.

Farmer opinions on management and administration of the scheme

Respondents generally felt that the staff of the CSF project were polite, technically competent and trustworthy (Table 2.1). Scores from 2006 reflected general agreement with the statements that staff were capable, and these scores had increased by 2008 in nearly all catchments. This reflects well on the attitude and performance of the staff. The reverse-worded question about the 'potential inefficiency' of the staff also showed a decreased score over time. This is consistent with the other responses, and shows both a high regard for the

staff and that the farmers were responding appropriately to the questions. It is also noteworthy that at the start of the project farmers were tending to suggest that there was a lot of paperwork associated with the project. However, by 2008 their opinions had changed and they tended to disagree with this suggestion.

Table 2.1. Mean score for Likert scale questions relating to CSF staff and the structure of the scheme in 2006 and 2008 for each catchment individually and overall. 1=strongly disagree; 2=disagree; 3=don't know; 4=agree; 5=strongly agree. 93 farmers responded to the overall questionnaire but only 90 responded to these questions in 2006 and 73 in 2008.

Item	Catchment	Year	
		2006	2008
"The staff working on the catchment sensitive demonstration project are courteous and helpful"	Twrch	4	4.06
	Llafar	3.73	4.13
	Deepford Brook	4.22	4.46
	Overall	***3.99***	***4.22***
"The staff working on the CSF demonstration project are technically competent"	Twrch	3.35	3.65
	Llafar	3.55	3.59
	Deepford Brook	3.86	3.92
	Overall	***3.63***	***3.72***
"The staff on the CSF demonstration project are trustworthy"	Twrch	3.45	3.82
	Llafar	3.64	3.71
	Deepford Brook	4	3.96
	Overall	***3.74***	***3.82***
"The staff working on the catchment sensitive farming project are amongst the most inefficient Government officials I have ever met"	Twrch	2.35	2.41
	Llafar	2.33	2.03
	Deepford Brook	1.97	1.64
	Overall	***2.19***	***2.01***
"There is a lot of paperwork associated with the CSF project"	Twrch	3.5	2.71
	Llafar	3.27	2.66
	Deepford Brook	3.03	2.72
	Overall	***3.22***	***2.73***

The responses of the farmers to the open questions also showed similar trends to those shown by the Likert-type statements (Appendix 4). For example when first asked about the practicality of the scheme there was widespread concern among farmers about the practicality of fencing off streams:

I have a big question mark over the effectiveness of fencing streams. I think this is unnecessary as animals have been drinking from ditches and streams for centuries

Fencing the river banks is impractical as the first strong flow will break the fence anyway. The fact that they can't put rocks in the river corners to try and reduce erosion and to stop the river eating into the land is also impractical. I feel that the plan once again limits the farmer.

By 2008 some farmers still voiced concerns over the impracticality of fencing, but the general tone of the comments was more conciliatory; with concerns relating more to specific issues of

scheme administration which may have affected them (e.g. slow payments, contradictory advice from different organizations) and philosophical issues about inclusion and outcomes.

We were asked to complete diaries, but we had to wait 8-10 months for them – no purpose for this. Also it's a pity that the project was hurried in the end.

The project should include Lliw and Dyfrdwy if you are going to have any real difference in the water quality in the lake

I saw the project as quite useful but the percentage of money going towards administrating the project was too high.

All quite rational the way they come out and look at things. It is all geared towards the ultimate objective to reduce pollution.

Farmer opinions on purpose and philosophy of the scheme

Generally, respondents disagreed with the statement that 'managing water quality at the catchment scale was a silly idea'; and interestingly their overall level of disagreement increased over the course of the project (Table 2.2). This suggests that the benefits of catchment scale management became more apparent to the farmers as the scheme progressed. Similarly, there was a general feeling that the actions on individual farmers could have an impact on the overall quality of water in the catchment; and again the strength of feeling on this issue tended to increase over the duration of the project. It was also interesting to note that farmers would be embarrassed if their neighbours thought they were polluting the rivers, and again the strength of feeling on this issue increased between 2006 and 2008. Taken together, these results suggest that farmers do recognize the benefits of catchment scale management; they do think that individual actions matter, and they feel there is a social stigma associated with being identified as a polluter.

However, there was less cohesion in the responses to the statement that 'Public opinion should not dictate environmental policy on farms'. Farmers in Deepford tended to strongly agree with this statement in 2006; and although the level of agreement had decreased by 2008, the strength of feeling in Deepford was still greater than in the other two catchments. Farmers in the Twrch and the Llafar were more sanguine about this statement although they tended to agree with it.

Table 2.2 Mean score for Likert scale questions relating to purpose and philosophy of the scheme in 2006 and 2008 for each catchment individually and overall. 1=strongly disagree; 2=disagree; 3=don't know; 4=agree; 5=strongly agree. 93 farmers responded to the overall questionnaire but only 90 responded to these questions in 2006 and 73 in 2008.

Item	Catchment	Year	
		2006	2008
"I would be embarrassed if my neighbours thought I was polluting the river"	Twrch	4.5	4.76
	Llafar	4.44	4.26
	Deepford Brook	4.05	4.12
	Overall	***4.13***	***4.32***
"It doesn't matter what I do on my farm, I can't have any real impact on improving the quality of streams and rivers in my area"	Twrch	2.05	1.82
	Llafar	2.61	2.91
	Deepford Brook	2.35	1.96
	Overall	***2.39***	***2.36***
"Managing water quality at the catchment scale is a silly idea"	Twrch	2.6	2
	Llafar	2.19	2.03
	Deepford Brook	2.08	2.04
	Overall	***2.24***	***2.03***
"Public opinion should not dictate environmental policy on farms"	Twrch	3.45	3.24
	Llafar	3.69	3.51
	Deepford Brook	4.19	3.92
	Overall	***3.84***	***3.58***
"Only if all the farmers in my area work together can we hope to see a major improvement in the quality of the water in the local streams and rivers"	Twrch	3.95	3.59
	Llafar	4.11	3.97
	Deepford Brook	3.78	3.84
	Overall	***3.95***	***3.84***

Similarly, there was a difference between catchments in the responses to the statement about farmers working together. In 2006 farmers in the Llafar showed high levels of agreement with this statement, although these levels fell a little by 2008; and although the initial levels of agreement was lower in the other two catchments, these levels also fell by 2008. This is an unexpected result for two reasons. Firstly, the Welsh Assembly Government had been promoting collaborative and partnership working over this time period. Secondly, responses to other questions had indicated farmers' general support for catchment-scale initiatives.

The responses to the open ended question 'How would you feel about joining with your neighbours in a formal scheme to improve water quality in the catchment?' showed a wide range of views associated with this issue (Appendix 4). While many farmers were happy in principle to work with their neighbours, others were wary about the potential difficulty of working effectively with neighbours over the long term. There was concern about 'taking on other people's problems', and also about the task of agreeing a suitable course of action, as evidenced by the quotes below:

In theory I would be reluctant to take on other farmers problems. i.e. if a neighbour was polluting the river with effluent or slurry I would not want to help with that.

Unsure. Depends on payments and the scheme requirements. Wouldn't want to fall out with neighbours about it.

I would be prepared to do that in principle.

I would be reluctant to join. Because I feel neighbours never work well together and it's up to each farmer to do his own bit to improve water quality.

Difficult to say until I se the details, but in principle I have no objections. It makes sense to work together

I'm happy to do this kind of work with my neighbours, as long as it continues to be voluntary. I would be against it if people were force into agreements together. It makes sense to focus on the same issues whilst aiming for a common goal.

Not likely to happen as farmers can't agree.

Always difficult to get farmers to agree. It would be better to have a plan for each farm individually and one official person to discuss every plan

The relationships between farmers and their immediate neighbours can be complex. Firstly they tend to be long-term, as few farmers move in or out of an area during their lifetime. Secondly, there may be a different set of relationships between neighbouring farmers, spouses and children. Thirdly, these relationships may span the workplace, i.e. farmers helping each other; in local institutions such as chapel and school, and also in other less structured social situations. For this reason, any future schemes that require active collaboration between neighbours will need to be very sensitive to the complexity of the social relationships between neighbouring farms.

There was a clear difference of opinion between catchments about whether or not the catchment-sensitive farming demonstration project was 'a good use of money'. When asked in both 2006 and 2008, the majority of farmers in Deepford Brook felt that the scheme was a good use of money. However, farmers in the other catchments were less consistent in their views (Appendix 4). Many of the concerns raised related to the amount of money spent on administering the scheme. Although the farmers did not know the exact breakdown of the

expenditure, they felt that a lot was spent on administration and relatively little came to the farmers. Some of the farmers commented that the money would have been well spent if it had improved the water quality. However, they had not seen any official data on this and so were unable to comment. Interestingly, some farmers commented that the contractors benefited greatly from the scheme; and they also viewed the administrative and project staff as being 'them'. None of the farmers seemed to recognize that some of the WAG staff working on the project were likely to belong to farming families. For these reasons, many farmers did not perceive a major benefit of the project on the rural economy; although several individuals did make this wider connection:

Quite satisfied. It would have been better to spend on more long-term things like buildings and roads. Pads and fences could be destroyed in less than 5 years. Apart from that everything is a help. (2008)

I feel these kind of projects are often designed to safeguard 'white-collar' positions in the civil service (2006)

The environment is important, but I'm concerned how much money they will squander on administration (2006)

I find this difficult to believe. The shed contractors had the greatest benefit from the plan. As the work was hurried in the end, they had also raised their prices. (2008)

Honestly, no...well maybe. Went to meeting in Llawhaden- 12 of us there, 10 people telling us what to do. Waste of money. A lot of money into administration. Not much more money goes back to the farmer. (2008)

I'd go further, I'd say it was an excellent use of public money because of the social and economic effect it will have. Example: clean water=abundant aquatic life=healthy fish stocks =fishermen=revenue (2008)

Yes, we will never know if the higher percentage of work went to the right place. I feel that a lot of the money was spent on controlling/administrating the project. But in theory it's a good idea, with a good purpose. (2008)

It has helped to save pollution problems which mean that more than agriculture has benefited, like the tourist industry in the area. I would like to see the results from monitoring the water quality to see if there is any change.

When questioned in 2006 farmers in the Twrch catchment had a good understanding of what CSF was. Some of them stated that their knowledge was poor, which was understandable given that it was at the beginning of the scheme. Also, even though most farmers knew that CSF aimed to improve water quality, they expressed some scepticism as to whether or not any improvement was needed. There were also some queries as to how WAG expected to improve the quality of the water in Llyn Tegid by focusing only on agriculture in two small catchments. Evidently, these respondents had not fully understood the pilot nature of the project. The responses for 2008 were nearly all generally correct; although some of the queries raised in 2006 did still appear in some responses:

The purpose of CSF is to safeguard streams and rivers in a catchment area from pollution. However I don't feel there's a need for safeguarding rivers as they were here before people, and will be here after we've left. (2006)

A plan to try and improve the water quality in the rivers and in the lake. (2008)

I wouldn't have a clue because I haven't read or heard anything about CSF until your project contacted me. (2006)

CSF is about improving the water quality- yet I can't understand why the forestry isn't a part of the scheme. (2006)

Farmers in the Llafar catchment held similar views to those in the Twrch. Most knew something about the scheme although some level of scepticism was present. The responses in 2008 were nearly all correct, although it is interesting to note how some farmers speak of a 'plan' and other emphasise 'grants':

A plan where big brother is watching you. Need to go into it. Should be a plan to improve the river, and as I can see now there will not be a lot of effect. (2006)

To make the water in the local rivers purer. Grants available to improve farm buildings and to decrease pollution from the farm yard reaching the water in the streams. (2006)

To be honest, if I was speaking to another farmer I would start by saying CSF is yet another scheme where officials keep an eye on what we do as farmers and create mountains of paperwork. The official definition of CSF is a project that attempts to improve the water quality of Twrch and Llafar, but there are so many bodies and organisations responsible for this and the other already. Farmers don't want to see pollution, just like everybody else. (2006)

Good plan to keep farms tidy and also a plan that has created jobs for people. We have built sheds, some others have been fenced, concreting etc to improve Llyn Tegid water quality. (2008)

The responses in Deepford were of a similar tenor. Most responses in 2006 had a good idea as to the aims of the project, and by 2008 most farmers had a very good view on the purpose of CSF, although some negative issues remain.

Something about water quality and fencing off streams.

(farmer no.8 in 2006)

A project to improve water quality looking at how to reduce pollution from farms and livestock

(farmer no 8. In 2008)

Excellent. Something that makes life a lot easier for you and helps the environment. Something that needs to be done in all places. Couldn't have done the work without the grants. Now the ditches work wonderfully. (2008)

When asked in 2006 what the main benefits of CSF would be, farmers tended to be split into three groups: those who saw an opportunity for financial assistance to enhance the capital structures on their farms, those who felt that it would benefit the environment, and those who could not really see any benefit. It was also noticeable that farmers in Deepford Brook tended to cite the grant and the soil sampling scheme as the main benefits, more often than farmers in the other two catchments.

Not many benefits for the farmers nor the environment in reality. (2006)

Opportunity to improve the farm in terms of facilities such as manure storage and dipping. (2006)

I don't know enough to make that kind of assessment- ask me in a couple of years' time.

(farmer no.7 in 2006)

Farming that's sensitive to an area has been a win-win situation, as it has helped to improve the business and helped the environment. The soil analysis was very useful as it allowed me to know how to control the land.

(farmer no 7 in 2008)

Cleaner water in our streams and river and ensuring that the water is fit to drink. (2006)

Soil analysis will help us cut down on fertiliser.

(farmer in Deepford Brook, 2006)

Responses to the same question in 2008 were noticeably different in the Twrch catchment. Here, many farmers noted that the changes made under CSF had made both stock and manure management considerably easier. Similar comments were also made in the other two catchments. Several farmers also commented that they were now better able to comply with legislative requirements; and that felt they had reduced the risk of pollution. Some also noted that the scheme had benefitted the environment.

One aspect that I did like was the help for pads to ease feeding outside. (2008)

Less mucking out work for us and has therefore eased our work. It is easier to keep the farm clean as less water was mixed with the muck and slurry. Concrete has cleaned the farm also. I feel better now as I know there is less chance for me to poison the river. (2008)

No benefits for me but benefits to the water quality in the lake and local rivers. (2008)

Meeting cross-compliance regulations. Also environmental benefits. (2008)

Farmer opinions on water quality, pollution and mitigation

There was a general tendency amongst the farmers to disagree with the supposition that most pollution in the rivers is caused by farmers (Table 2.3). Whilst in the Twrch and in

Deepford the level of disagreement in 2008 increased relative to the 2006 score, it decreased slightly in the Llafar. However, the respondents seemed unsure as to whether water pollution was not caused by farmers. Scores in all three catchments were close to the mid-point on the scale (a value of 3); with farmers in Deepford seeming to state that farmers did cause pollution, while those in the other two catchments taking the opposite view.

There was a similar level of uncertainty in responses to the statement that 'rivers and streams on my farm are cleaner now than at any time in the last 20 years', although there was a weak tendency to agree with the statement. Between 2006 and 2008 the level of agreement increased in the Llafar and in Deepford, but not in the Twrch.

There was widespread acknowledgement that pollution can occur even if there are no visible signs or odours, and this opinion was almost constant between the sampling times. Respondents were a little doubtful if grassland buffers could stop the river getting polluted, and the level of doubt increased slightly between sampling periods. However, there was widespread agreement that muddy gateways could cause pollution, and that putting hard standing in gateways may have economic gains. There were no major shifts in the pattern of the responses to these two questions between 2006 and 2008.

When asked 'What changes would you make to your farm to improve water quality that are not already funded by catchment-sensitive farming?' a majority of farmers in the Twrch catchment mentioned a desire to bring back liming. Other issues raised included the need to include forestry in the scheme, and to improve buildings and drainage. A desire to fund liming was also mentioned by many farmers in the Llafar catchment; although many also stated that there was nothing else they could do to reduce pollution from their farms. The responses from Deepford were quite different; while many farmers did state there was nothing else they could do, several showed interest in installing reed beds, soakaways and rainwater harvesting.

By 2008, many of the farmers in the Twrch and the Llafar offered different answers to those offered in 2006. While liming was still mentioned by some, there was a wider range of suggestion for improving the water quality. Some stated that there was nothing further to be done; others said they would like to see the evidence that there was a pollution problem before they did any more work.

Stricter management of forestry in the area. The best thing that the officers could do is carry out spot-checks on the forestry people as they pollute by careless storing of diesel for machinery inadequately. CSF also needs to take into account the effect of pine trees as well. (2006)

Table 2.3. Mean score for Likert scale questions relating to water quality, pollution and mitigation in 2006 and 2008 for each catchment individually and overall. 1=strongly disagree; 2=disagree; 3=don't know; 4=agree; 5=strongly agree. 93 farmers responded to the overall questionnaire but only 90 responded to these questions in 2006 and 73 in 2008.

Item	Catchment	Year	
		2006	2008
Most of the pollution in our local rivers is caused by farmers	Twrch	2	1.71
	Llafar	1.83	2.09
	Deepford Brook	2.65	2.48
	Overall	***2.19***	***2.13***
If you cant see or smell pollution in a river then there isn't a major problem	Twrch	2.3	2.12
	Llafar	2.42	2.86
	Deepford Brook	2.62	2.4
	Overall	***2.47***	***2.55***
Grassland buffer strips along a river bank can't stop the river getting polluted	Twrch	3.1	3.41
	Llafar	3.17	3.29
	Deepford Brook	3.35	3.24
	Overall	***3.22***	***3.3***
Muddy gateways don't have any impact on the quality of the streams and rivers on my farms	Twrch	3.05	2.88
	Llafar	2.44	2.77
	Deepford Brook	2.76	2.48
	Overall	***2.7***	***2.7***
Putting hard standing in gateways is a waste of money	Twrch	1.95	2.06
	Llafar	2	2.14
	Deepford Brook	1.95	1.92
	Overall		***2.05***
The rivers and streams on my farm are cleaner now than at any time in the last 20 years	Twrch	3.2	3.06
	Llafar	3.03	3.29
	Deepford Brook	3.68	3.8
	Overall	***3.32***	***3.4***
Water pollution in my area is not caused by farmers	Twrch	3.2	3.41
	Llafar	3.42	3.8
	Deepford Brook	2.95	2.88
	Overall	***3.18***	***3.42***

Liming would help to improve water quality without a doubt. They used to support lime application, and CSF should start this again. (2006)

I would like more clear and concise information from one source rather than the 'mishmash' I receive from a number of different bodies, often contradicting each other. I would simply like to know what affects the water quality and why, then I would do something about it - we're not children! (2006)

I haven't got any other suggestion to be honest. I would like to know properly if there is a problem in the Twrch. Is it possible to see the results? (2008)

Include Llanuwchllyn sewerage system in any work to improve the standard of the water in the area. (2008)

Only thing that could be done is to cover more yards. (2008)

Farmer opinions on fertilisers and nutrient management

In 2006, farmers in all catchments expressed a strong view that all the fertiliser they applied helped to enhance the farm's profitability (Table 2.4). However, support for this statement had decreased in all catchments by 2006. This decrease was greatest in the Twrch and least in Deepford Brook. All farmers supported the need to calculate fertiliser application rates according to situation, and the support for this statement had increased by 2008 in the Twrch and the Llafar. In line with these responses most farmers in 2006 disagreed with the statement that if in doubt it was better to use too much fertiliser than too little. By 2008 the level of support for this statement had decreased considerably in all catchments.

There was a general level of agreement that fertiliser could impact the environment. Similarly most farmers agreed that they considered the amount of nutrients they had applied in their slurry / manure when estimating fertiliser application rates. Overall the support for both of these statements increased between 2006 and 2008.

There is a potential illogicality about the responses to the two statements: 'I always apply manure/slurry to my land when the grass most needs it' and 'I take advantage of frozen ground conditions to spread manure and slurry during the winter'. There was slight agreement with both statements in 2006 and 2008. However, this seems to pose some problems; as it is highly unlikely that grass will be growing when the ground is frozen. One explanation for this is that some farmers are responding strongly to one or both of these statements, but this variability is being lost when the average scores are being calculated. Alternatively, farmers are engaging in both practices; and are unsure how to respond. In other words they do take advantage of frozen ground when they have to, but they also try to apply manure when it is most needed.

Interpretation of the results becomes even more difficult when responses to a third question 'I spread slurry/manure when it is convenient' are considered. In 2006 most farmers showed agreement with this question, which again seems to contradict the responses to the previous two questions. However, by 2008 the average level of agreement with this statement had decreased in all catchments.

There was a high level of support for preventing manure running into streams and ditches, which stayed constant between 2006 and 2008. There was also general disagreement with the suggestion that nutrient analysis of soils was a waste of money. Farmers in the Twrch and in Deepford tended to disagree more strongly with this statement in 2008 than in 2006, but the reverse was true in the Llafar.

Table 2.4 Mean score for Likert scale questions relating to fertilisers and nutrient management in 2006 and 2008 for each catchment individually and overall. 1=strongly disagree; 2=disagree; 3=don't know; 4=agree; 5=strongly agree. 93 farmers responded to the overall questionnaire but only 90 responded to these questions in 2006 and 73 in 2008.

Item	Catchment	Year	
		2006	2008
All the fertiliser I apply helps improve the farm profitability	Twrch	4.05	3.06
	Llafar	4.03	3.82
	Deepford Brook	4.13	4.08
	Overall	***4.07***	***3.73***
I always apply manure/slurry to my land when the grass most needs it	Twrch	3.9	3.65
	Llafar	3.22	3.58
	Deepford Brook	3.81	3.42
	Overall	***3.6***	***3.54***
I take advantage of frozen ground conditions to spread manure and slurry during the winter	Twrch	3.05	3.06
	Llafar	3.12	2.85
	Deepford Brook	3	3.25
	Overall	***3.07***	***3.03***
If in doubt, it is better to use too much fertiliser than too little	Twrch	2.55	1.88
	Llafar	2.11	2.03
	Deepford Brook	2.3	1.92
	Overall	***2.28***	***1.96***
It is important to carefully calculate fertiliser requirements based on stocking, land use, manure usage and soil analysis	Twrch	4.1	4.18
	Llafar	4.14	4.36
	Deepford Brook	4.11	3.88
	Overall	***4.11***	***4.16***
Manure and slurry applications have little effect on the amount of bag fertiliser that is needed	Twrch	2.35	2.06
	Llafar	1.97	2
	Deepford Brook	2.11	1.83
	Overall	***2.11***	***1.96***
Nutrient analysis of soil is a waste of money	Twrch	1.65	1.47
	Llafar	1.61	2.58
	Deepford Brook	1.92	1.71
	Overall	***1.74***	***1.81***
The amount of fertiliser that farmers use has little affect on the environment	Twrch	2.65	2
	Llafar	2.67	2.58
	Deepford Brook	2.54	2.5
	Overall	***2.61***	***2.42***
I spread slurry/manure when it is convenient	Twrch	3.35	3.24
	Llafar	3.5	2.79
	Deepford Brook	3.13	3.42
	Overall	***3.32***	***3.09***
I try my best to stop manure from running off the farm yard into streams and ditches	Twrch	4.55	4.53
	Llafar	4.19	4.16
	Deepford Brook	4.35	4.33
	Overall	***4.33***	***4.3***

Adoption and non-adoption

By July 2008, 57 % of farmers in the three catchments had joined the scheme, and 27 % had not joined. Participation may increase in the future since the remaining farmers have either not yet decided, have not completed assessment or did not respond to the final questionnaire.

The manner in which eligible farmers heard about the CSF project varied quite considerably. Many first heard of it from a letter sent to them by the organizers inviting them to a local meeting. However, a significant proportion heard about it from other sources including the media, friends and contacts in the agricultural world. Some farmers claimed to have heard about the project only when they were contacted by members of the evaluation team. It is clear from these responses that several channels of communication are needed in order to

inform farmers, and it would be wrong to assume that all farmers will be adequately informed from a single letter.

Would you do it again?

In the 2008 survey all farmers who had joined the CSF scheme were asked 'Looking back to 2006 and knowing what you know now – do you think that if you had the time again you would join the Catchment-sensitive Farming Demonstration Project?'. Forty-six farmers responded positively that they would join again, while 5 responded that they would not (Table 2.5). The reasons given for not joining the scheme again related to farmers not seeing a need for more pollution prevention work, lack of money for match funding and issues relating to staff and administration.

I would definitely. We need to take an advantage on everything but I would like to see more help for young people.

I wouldn't rush to join even if I had the money. The plan needs to employ people that understand farming better.

I don't regret being part of the plan and I would recommend it to any other farmer.

I would, if a grant was available. There are enough things to do on the farm again to improve water quality. But, the grant would have to be enough. Even though the grant is 60% this time the farmer had to find the rest.

I would, probably. It has been a good advantage to us here, helping work from day to day and also hopefully improving water quality.

Yes. Definitely. Bit wary in the beginning. Worried about people looking into the farm and poking into things. Staff very approachable and know what they were talking about. Easy to get and phone. No problems with people looking where they shouldn't.

Yes-definitely. Made the winter so much easier- feeding cattle and a concrete yard and under cover and less dirty water.

Almost all the farmers who answered this question are still positive about having joined the CSF project. Five farmers felt that they could have got more out of the project.

Only five farmers felt that, with hindsight, they would not have joined the project. Four of these gave the reason that 'there is nothing left to do', implying that CSF has already made all the changes necessary on their farms.

Table 2.5 Responses to the question ''Looking back to 2006 and knowing what you know now – do you think that if you had the time again you would join the Catchment-sensitive Farming Demonstration Project ?' for each catchment individually and overall.

Response	Catchment		
	Twrch	Llafar	Deepford Brook
Not in scheme	3	3	3
Yes	**10**	**13**	**23**
Specific comments made:			
Yes, and would do better next time	3	1	1
Yes, despite the project (funding) being too limited	2	1	1
Yes, despite problems	1		1
Yes, and staff were very good			1
No	**1**	**3**	**1**
Specific comments made:			
No – nothing necessary to do		2	
No - too much administrative burden and nothing now needs doing		1	
No - no spare money and staff don't understand farming	1		

Did farmer attitudes change as a result of participation in the project?

Whether taking part in the CSF project or not, farmers rate environmental issues highly. As a group, they agree with many of the principles of CSF, but have mixed attitudes towards responsibility for managing and funding water quality and the environment.

Over the duration of the CSF project there have been numerous subtle shifts in farmers' attitudes (Table 2.6). The two strongest changes have been that farmers view environmental pressure groups more positively; and their increased sense of responsibility (at least partly) for local water quality.

Farmers in the three pilot catchments respond differently to most (16 out of 21) of these statements. There is even less consensus (i.e. a broader range of responses to each question) in Twrch than in the other two catchments. Most notably:

Environmental pressure groups: farmers in Deepford and Twrch are now more positive about the role of pressure groups in farming, while there has been no change in attitudes in Llafar.

Good farming always leads to a good environment: farmers in Deepford and Llafar consistently agree with this statement but in Twrch farmers are now less certain, perhaps recognising that farming can negatively influence the environment.

Legislation on water quality helps the farmer: in Deepford farmers are now less sure of this than they were in 2006. Llafar farmers still disagree with the statement, whereas Twrch farmers still agree.

Most local pollution is caused by farmers: all farmers in all catchments now disagree with this statement; in 2006 Deepford farmers were less certain.

Unmanaged buffer strips look untidy: farmers in Deepford and Twrch now disagree with this statement whereas in 2006 they agreed. Opinions in Llafar catchment have not changed.

In 2006, most farmers in Twrch disregarded the potential influence of muddy gateways on water quality, but in 2008 all catchments agreed that they can have an impact.

In all catchments farmers feel that water quality is better in 2008 than it was in 2006.

Table 2.6. CSF farmers' responses to the 21 attitude questions used in both CSF and public questionnaires.

	Question text	Year	blank (n)	Percentage of responses in each category				
				Strongly disagree	Disagree	Don't know	Agree	Strongly agree
1	Environmental pressure groups are unhelpful to farmers	2006	1	4.30	21.51	25.81	**44.09**	3.23
		2008	1	1.30	**35.06**	24.68	33.77	3.90
2	Good farming always leads to a good environment	2006		1.08	13.98	5.38	**63.44**	16.13
		2008		1.30	23.38	7.79	**57.14**	10.39
3	Government legislation on water quality is helpful to the farmer	2006		2.17	33.70	23.91	**39.13**	1.09
		2008			35.06	19.48	**44.16**	1.30
4	Most of the pollution in our local rivers is caused by farmers	2006		26.88	**38.71**	24.73	7.53	2.15
		2008		16.88	**62.34**	12.99	6.49	1.30
5	Unmanaged buffer strips around fields and along riverbanks make the farm look untidy	2006		1.08	30.11	8.60	**54.84**	5.38
		2008			37.66	11.69	**48.05**	2.60
6	I would be embarrassed if my neighbours thought I was polluting the river	2006				4.30	**61.29**	34.41
		2008			1.30		**63.64**	35.06
7	If you can't see or smell pollution in a river then there isn't a major problem	2006		7.53	**55.91**	19.35	16.13	1.08
		2008		10.39	**51.95**	11.69	24.68	1.30
8	It is good stock management to keep livestock away from watercourses	2006	1	4.30	32.26	2.15	**59.14**	1.08
		2008		6.49	37.66	7.79	**46.75**	1.30
9	It is important to carefully calculate fertiliser requirements based on stocking, land use, manure usage and soil analysis	2006			3.23	3.23	**72.04**	21.51
		2008	2		1.30	3.90	**75.32**	16.88
10	It is important to have some areas of natural habitat on the farm	2006			1.08	6.45	**73.12**	19.35
		2008				1.30	**76.62**	22.08
11	Grassland buffer strips along a river bank can't stop the river getting polluted	2006			32.26	16.13	**48.39**	3.23
		2008	1		24.68	16.88	**55.84**	1.30
12	Managing water quality at the catchment scale is a silly idea	2006		7.53	**69.89**	15.05	6.45	1.08
		2008		7.79	**85.71**	2.60	3.90	
13	Muddy gateways don't have any impact on the quality of the streams and rivers on my farms	2006		3.23	**56.99**	6.45	33.33	
		2008		2.60	**54.55**	12.99	29.87	
14	Production efficiency should be the first priority of farmers	2006	1		9.68	7.53	**73.12**	8.60
		2008			25.97	7.79	**64.94**	1.30
15	Public opinion should not dictate environmental policy on farms	2006	1	2.15	8.60	3.23	**69.89**	15.05
		2008		1.30	18.18	12.99	**55.84**	11.69
16	The Government should pay for improvements in the environment	2006			3.23	6.45	**69.89**	20.43
		2008			2.60	5.19	**85.71**	6.49
17	Only if all the farmers in my area work together can we hope to see a major improvement in the quality of the water in the local streams and rivers	2006			8.60	3.23	**73.12**	15.05
		2008			6.49	5.19	**85.71**	2.60
18	Rivers and streams are important wildlife habitats on my farm	2006			4.30	1.08	**73.12**	21.51
		2008			1.30	2.60	**70.13**	25.97
19	The amount of fertiliser that farmers use has little affect on the environment	2006		7.53	**48.39**	19.35	24.73	
		2008	1	6.49	**64.94**	12.99	14.29	
20	The rivers and streams on my farm are cleaner now than at any time in the last 20 years	2006	1	1.09	15.22	35.87	**41.30**	5.43
		2008	1		14.29	28.57	**53.25**	2.60
21	Water pollution in my area is not caused by farmers	2006	2	2.15	15.05	**47.31**	25.81	7.53
		2008			20.78	23.38	**49.35**	6.49

Table 2.7 CSF farmers' responses to the attitude questions, separated by year and catchment (Questions 1 to 10)

	Question text	Catchment	Year	blank (n)	Percentage of responses in each category				
					Strongly disagree	Disagree	Don't know	Agree	Strongly agree
1	Environmental pressure groups are unhelpful to farmers	**Deepford**	2006			21.62	13.51	**59.46**	5.41
			2008			**40.00**	20.00	36.00	4.00
		Llafar	2006		2.78	22.22	27.78	**44.44**	2.78
			2008	1		22.86	28.57	**42.86**	2.86
		Twrch	2006	1	15.00	20.00	**45.00**	15.00	
			2008		5.88	**52.94**	23.53	11.76	5.88
2	Good farming always leads to a good environment	Deepford	2006			10.81	5.41	**70.27**	13.51
			2008			16.00		**68.00**	16.00
		Llafar	2006		2.78	16.67	5.56	**55.56**	19.44
			2008		2.86	20.00	5.71	**60.00**	11.43
		Twrch	2006			15.00	5.00	**65.00**	15.00
			2008			**41.18**	23.53	35.29	
3	Government legislation on water quality is helpful to the farmer	**Deepford**	2006			22.22	**41.67**	36.11	
			2008			28.00	32.00	**36.00**	4.00
		Llafar	2006			**47.22**	8.33	44.44	
			2008			**42.86**	17.14	40.00	
		Twrch	2006		10.00	30.00	20.00	**35.00**	5.00
			2008			29.41	5.88	**64.71**	
4	Most of the pollution in our local rivers is caused by farmers	**Deepford**	2006		5.41	37.84	**43.24**	13.51	
			2008		12.00	**44.00**	28.00	16.00	
		Llafar	2006		41.67	**44.44**	5.56	5.56	2.78
			2008		5.71	**85.71**	5.71		2.86
		Twrch	2006		**40.00**	30.00	25.00		5.00
			2008		**47.06**	41.18	5.88	5.88	
5	Unmanaged buffer strips around fields and along riverbanks make the farm look untidy	**Deepford**	2006			37.84	8.11	**54.05**	
			2008			**44.00**	16.00	36.00	4.00
		Llafar	2006		2.78	33.33	5.56	**55.56**	2.78
			2008			25.71	5.71	**65.71**	2.86
		Twrch	2006			10.00	15.00	**55.00**	20.00
			2008			**52.94**	17.65	29.41	
6	I would be embarrassed if my neighbours thought I was polluting the river	Deepford	2006				8.11	**78.38**	13.51
			2008			4.00		**76.00**	20.00
		Llafar	2006				2.78	**50.00**	47.22
			2008					**74.29**	25.71
		Twrch	2006					**50.00**	**50.00**
			2008					23.53	**76.47**
7	If you can't see or smell pollution in a river then there isn't a major problem	Deepford	2006		2.70	**45.95**	37.84	13.51	
			2008		12.00	**56.00**	12.00	20.00	
		Llafar	2006		8.33	**63.89**	5.56	22.22	
			2008		2.86	**45.71**	14.29	37.14	
		Twrch	2006		15.00	**60.00**	10.00	10.00	5.00
			2008		23.53	**58.82**	5.88	5.88	5.88
8	It is good stock management to keep livestock away from watercourses	Deepford	2006			16.22		**81.08**	2.70
			2008			12.00	4.00	**80.00**	4.00
		Llafar	2006		2.78	44.44	5.56	**47.22**	
			2008		5.71	**42.86**	8.57	**42.86**	
		Twrch	2006	1	15.00	**40.00**		**40.00**	
			2008		17.65	**64.71**	11.76	5.88	
9	It is important to carefully calculate fertiliser requirements based on stocking, land use, manure usage and soil analysis	Deepford	2006					**89.19**	10.81
			2008	2			4.00	**80.00**	8.00
		Llafar	2006			2.78	5.56	**66.67**	25.00
			2008				5.71	**77.14**	17.14
		Twrch	2006			10.00	5.00	**50.00**	35.00
			2008			5.88		**64.71**	29.41
10	It is important to have some areas of natural habitat on the farm	Deepford	2006				2.70	**86.49**	10.81
			2008					**88.00**	12.00
		Llafar	2006				5.56	**69.44**	25.00
			2008					**82.86**	17.14
		Twrch	2006			5.00	15.00	**55.00**	25.00
			2008				5.88	**47.06**	**47.06**

(Questions 11 to 21)

	Question text	Catchment	Year	blank (n)	Percentage of responses in each category				
					Strongly disagree	Disagree	Don't know	Agree	Strongly agree
11	Grassland buffer strips along a river bank can't stop the river getting polluted	Deepford	2006			24.32	21.62	**48.65**	5.41
			2008	1		20.00	20.00	**56.00**	
		Llafar	2006			36.11	11.11	**52.78**	
			2008			28.57	14.29	**57.14**	
		Twrch	2006			**40.00**	15.00	**40.00**	5.00
			2008			23.53	17.65	**52.94**	5.88
12	Managing water quality at the catchment scale is a silly idea	Deepford	2006		5.41	**83.78**	8.11	2.70	
			2008		12.00	**80.00**		8.00	
		Llafar	2006		8.33	**72.22**	11.11	8.33	
			2008		8.57	**82.86**	5.71	2.86	
		Twrch	2006		10.00	**40.00**	35.00	10.00	5.00
			2008			**100.00**			
13	Muddy gateways don't have any impact on the quality of the streams and rivers on my farms	Deepford	2006		2.70	**56.76**	2.70	37.84	
			2008		8.00	**56.00**	16.00	20.00	
		Llafar	2006		2.78	**72.22**	2.78	22.22	
			2008			**57.14**	8.57	34.29	
		Twrch	2006		5.00	30.00	20.00	**45.00**	
			2008			**47.06**	17.65	35.29	
14	Production efficiency should be the first priority of farmers	Deepford	2006			5.41	5.41	**81.08**	8.11
			2008			28.00	4.00	**68.00**	
		Llafar	2006	1		5.56	11.11	**69.44**	11.11
			2008			20.00	8.57	**71.43**	
		Twrch	2006			25.00	5.00	**65.00**	5.00
			2008			35.29	11.76	**47.06**	5.88
15	Public opinion should not dictate environmental policy on farms	Deepford	2006					**81.08**	18.92
			2008			4.00	16.00	**64.00**	16.00
		Llafar	2006		2.78	13.89	5.56	**66.67**	11.11
			2008		2.86	20.00	8.57	**60.00**	8.57
		Twrch	2006	1	5.00	15.00	5.00	**55.00**	15.00
			2008			**35.29**	17.65	**35.29**	11.76
16	The Government should pay for improvements in the environment	Deepford	2006			5.41	2.70	**81.08**	10.81
			2008			8.00	16.00	**72.00**	4.00
		Llafar	2006				8.33	**75.00**	16.67
			2008					**94.29**	5.71
		Twrch	2006			5.00	10.00	40.00	**45.00**
			2008					**88.24**	11.76
17	Only if all the farmers in my area work together can we hope to see a major improvement in the quality of the water in the local streams and rivers	Deepford	2006			10.81	5.41	**78.38**	5.41
			2008			8.00	4.00	**84.00**	4.00
		Llafar	2006			5.56		**72.22**	22.22
			2008			2.86		**94.29**	2.86
		Twrch	2006			10.00	5.00	**65.00**	20.00
			2008			11.76	17.65	**70.59**	
18	Rivers and streams are important wildlife habitats on my farm	Deepford	2006			2.70	2.70	**89.19**	5.41
			2008					**68.00**	32.00
		Llafar	2006			5.56		**75.00**	19.44
			2008			2.86	2.86	**80.00**	14.29
		Twrch	2006			5.00		40.00	**55.00**
			2008				5.88	**52.94**	41.18
19	The amount of fertiliser that farmers use has little affect on the environment	Deepford	2006		5.41	**51.35**	27.03	16.22	
			2008		4.00	**68.00**	12.00	16.00	
		Llafar	2006		5.56	**55.56**	5.56	33.33	
			2008	1	5.71	**57.14**	14.29	20.00	
		Twrch	2006		15.00	**30.00**	**30.00**	25.00	
			2008		11.76	**76.47**	11.76		
20	The rivers and streams on my farm are cleaner now than at any time in the last 20 years	Deepford	2006	1		10.81	21.62	**54.05**	10.81
			2008				24.00	**72.00**	4.00
		Llafar	2006			22.86	**42.86**	34.29	
			2008	1		17.14	28.57	**48.57**	2.86
		Twrch	2006		5.00	10.00	**50.00**	30.00	5.00
			2008			29.41	**35.29**	**35.29**	
21	Water pollution in my area is not caused by farmers	Deepford	2006	1		18.92	**64.86**	13.51	
			2008			36.00	**40.00**	24.00	
		Llafar	2006		5.56	13.89	30.56	**33.33**	16.67
			2008			8.57	8.57	**77.14**	5.71
		Twrch	2006	1		10.00	**45.00**	35.00	5.00
			2008			23.53	**29.41**	**29.41**	17.65

Table 2.8. Public responses to the 21 attitude questions, separated by year.

	Question text	Year	blank (n)	Percentage of responses in each category				
				Strongly disagree	Disagree	Don't know	Agree	Strongly agree
2	Environmental pressure groups are unhelpful to farmers	2006		6.67	28.57	25.40	**34.29**	5.08
		2007	5	5.82	**30.82**	27.74	28.77	5.14
		2008	26	2.37	28.11	19.82	**35.80**	6.21
3	Good farming always leads to a good environment	2006		2.22	18.10	6.03	**55.24**	18.41
		2007	5	1.71	14.38	7.88	**54.11**	20.21
		2008		0.89	15.09	8.88	**60.95**	14.20
4	Government legislation on water quality is helpful to the farmer	2006	2	6.35	22.86	26.98	**40.95**	2.22
		2007	5	2.05	20.89	30.82	**41.44**	3.08
		2008	2	4.44	27.22	26.63	**37.87**	3.25
11	Most of the pollution in our local rivers is caused by farmers	2006		25.08	**48.57**	15.87	9.84	0.63
		2007	4	15.07	**48.97**	18.15	15.75	0.68
		2008	1	23.37	**43.79**	11.24	18.64	2.66
12	Unmanaged buffer strips around fields and along riverbanks make the farm look untidy	2006		11.75	**38.41**	9.84	36.19	3.81
		2007	3	13.01	**38.36**	9.93	33.22	4.45
		2008	1	13.31	**44.67**	8.28	31.07	2.37
15	I would be embarrassed if my neighbours thought I was polluting the river	2006		0.00	1.27	5.71	**45.08**	47.94
		2007	9	0.34	3.08	1.71	**49.66**	42.12
		2008		0.30	2.07	1.48	**55.62**	40.53
19	If you can't see or smell pollution in a river then there isn't a major problem	2006		24.76	**55.24**	7.94	11.43	0.63
		2007	3	26.37	**55.48**	7.53	9.59	0.00
		2008	1	23.96	**58.88**	6.21	9.76	0.89
21	It is good stock management to keep livestock away from watercourses	2006	1	7.30	**32.38**	23.17	31.43	5.40
		2007	3	4.45	27.05	23.63	**40.41**	3.42
		2008	2	4.73	34.02	17.75	**40.24**	2.66
23	It is important to carefully calculate fertiliser requirements based on stocking, land use, manure usage and soil analysis	2006		0.32	1.90	8.89	**57.46**	31.43
		2007	4	0.68	0.34	9.25	**56.51**	31.85
		2008		0.00	1.18	7.99	**63.31**	27.51
24	It is important to have some areas of natural habitat on the farm	2006		0.63	2.86	2.22	**53.65**	40.63
		2007	4	1.71	1.03	2.05	**60.62**	33.22
		2008		0.30	2.37	0.59	**59.76**	36.98
25	Grassland buffer strips along a river bank can't stop the river getting polluted	2006		1.59	19.37	26.67	**45.71**	6.67
		2007	4	0.00	24.32	29.45	**41.10**	3.77
		2008	1	2.07	22.78	22.78	**49.41**	2.66
26	Managing water quality at the catchment scale is a silly idea	2006		14.60	**45.08**	25.71	12.70	1.90
		2007	3	9.93	**41.10**	38.01	8.90	1.03
		2008	1	9.17	**46.15**	26.63	16.86	0.89
29	Muddy gateways don't have any impact on the quality of the streams and rivers on my farms	2006		3.81	**33.33**	30.48	28.25	4.13
		2007	7	3.08	**32.19**	29.11	31.51	1.71
		2008	1	2.07	**35.50**	26.04	33.43	2.66
31	Production efficiency should be the first priority of farmers	2006		4.44	27.94	10.48	**43.81**	13.33
		2007	5	4.11	33.56	8.90	**39.38**	12.33
		2008		1.48	33.14	7.40	**43.79**	14.20
33	Public opinion should not dictate environmental policy on farms	2006		2.22	17.78	7.62	**51.11**	21.27
		2007	3	4.79	21.58	7.53	**53.77**	11.30
		2008	2	0.59	19.23	7.40	**50.89**	21.30
35	The Government should pay for improvements in the environment	2006		0.32	11.46	8.28	**58.92**	21.02
		2007	5	0.00	10.27	6.16	**60.96**	20.89
		2008		0.00	12.72	5.62	**61.83**	19.82
36	Only if all the farmers in my area work together can we hope to see a major improvement in the quality of the water in the local streams and rivers	2006		0.95	8.57	13.33	**60.32**	16.83
		2007	5	0.68	11.30	14.04	**62.67**	9.59
		2008	2	1.48	20.12	8.28	**60.65**	8.88
40	Rivers and streams are important wildlife habitats on my farm	2006		0.32	0.95	1.90	**55.24**	41.59
		2007	3	0.00	1.03	0.34	**59.93**	37.67
		2008		0.00	1.48	1.48	**60.65**	36.39
41	The amount of fertiliser that farmers use has little affect on the environment	2006		20.00	**48.57**	11.75	16.83	2.86
		2007	3	21.58	**50.68**	13.70	12.67	0.34
		2008		17.46	**52.37**	10.06	19.23	0.89
42	The rivers and streams on my farm are cleaner now than at any time in the last 20 years	2006	1	2.22	13.65	33.02	**41.90**	8.89
		2007	3	1.37	13.36	**43.84**	35.62	4.79
		2008	2	1.78	10.36	35.21	**44.67**	7.40
45	Water pollution in my area is not caused by farmers	2006	2	1.59	16.19	31.75	**35.87**	13.97
		2007	4	2.40	19.86	**36.99**	32.53	6.85
		2008	1	1.78	28.99	25.44	**37.28**	6.21

Environmental awareness in the population as a whole is also changing, which must be taken into account during the analysis of farmers' attitudes over the duration of CSF. Four questions highlight differences in public attitudes between years. Public opinion of environmental pressures groups is changing, but not in any consistent direction. The public consider that water quality is better now than in the last 20 years, and are unsure whether farmers are responsible for water quality issues; with as many people agreeing as disagree with this statement.

Simplifying the changes in farmers' attitudes

Factor analysis simplified these changes in farmer and public attitudes by reducing the 21 questions to five significant factors (Table 2.9). Each question is associated with at least one of these factors. Together these factors explain half the variation in questionnaire responses. Listed in order of their influence on attitudes they are:

(i) 'Wildlife-awareness'
(ii) 'Good farmers know best'
(iii) 'It's not the farmers' fault'
(iv) 'Farmers can't fix it'
(v) 'Legislate and cooperate'

How have the public's attitudes (baseline data) changed?

People in different age categories had significantly different attitudes to these environmental issues. People in the 45 – 54 age range were the group most certain that good farming is good for the environment and that farmers cannot fix environmental problems; scoring significantly higher than the other age groups for 'good farmers know best', 'it's not the farmers' fault' and 'farmers can't improve things'. In contrast, younger people (in the age range 25 – 34) were the most wildlife-aware.

Women were more wildlife-aware than men, whereas men felt more strongly that farmers can't improve the environment.

Respondents completing questionnaires in Welsh were less positive about farmers' ability to improve the environment, but were also more positive about legislation and cooperation. English questionnaires were consistently more wildlife-aware.

Table 2.9. The 21 attitude questions and how they relate to the five factors. The number in brackets under the factor number in the first row of the table indicates the amount of variation (in responses) explained by that factor. Each of the 21 questions is scored to indicate how strongly it is associated to each factor. The questions are listed in order of their association to the six factors, with the strongest factor and highest scores first.

	Question text	Farmer Factors (cumulative 44.45% of variation) "Wildlife - aware" (18.095)	"Good farmers know best" (8.630)	"It's not the farmers' fault" (7.261)	"Farming can't fix it" (5.381)	"Legislate and cooperate" (5.087)
18	Rivers and streams are important wildlife habitats on my farm	**0.76**	*-0.03*	0.06	0.11	0.07
10	It is important to have some areas of natural habitat on the	**0.70**	*-0.09*	*-0.00*	0.10	0.16
6	I would be embarrassed if my neighbours thought I was polluting the river	**0.67**	*-0.05*	0.28	0.09	0.21
9	It is important to carefully calculate fertiliser requirements based on stocking, land use, manure usage and soil analysis	**0.62**	0.34	*-0.10*	0.07	*-0.04*
5	Unmanaged buffer strips around fields and along riverbanks make the farm look untidy	***-0.34***	0.33	*-0.03*	0.19	0.24
19	The amount of fertiliser that farmers use has little affect on the environment	***-0.37***	0.15	0.32	0.05	0.10
20	The rivers and streams on my farm are cleaner now than at any time in the last 20 years	0.06	**0.59**	0.13	*-0.36*	*-0.03*
1	Environmental pressure groups are unhelpful to farmers	*-0.20*	**0.58**	*-0.04*	0.04	*-0.30*
15	Public opinion should not dictate environmental policy on	*-0.03*	**0.50**	0.09	0.18	*-0.32*
14	Production efficiency should be the first priority of farmers	*-0.05*	**0.49**	0.16	0.08	0.03
2	Good farming always leads to a good environment	0.05	**0.47**	0.01	0.02	0.36
16	The Government should pay for improvements in the	0.21	**0.34**	0.16	0.09	0.09
21	Water pollution in my area is not caused by farmers	0.08	0.22	**0.75**	0.02	0.02
8	It is good stock management to keep livestock away from	*-0.01*	0.26	***-0.46***	*-0.28*	0.24
4	Most of the pollution in our local rivers is caused by farmers	*-0.09*	*-0.27*	***-0.75***	0.18	0.11
11	Grassland buffer strips along a river bank cant stop the river getting polluted	0.29	0.18	*-0.32*	**0.71**	*-0.11*
13	Muddy gateways don't have any impact on the quality of the streams and rivers on my farms	0.14	*-0.12*	0.20	**0.70**	*-0.14*
12	Managing water quality at the catchment scale is a silly idea	*-0.21*	*-0.01*	0.10	**0.48**	*-0.01*
3	Government legislation on water quality is helpful to the farmer	0.06	*-0.21*	*-0.08*	*-0.10*	**0.70**
17	Only if all the farmers in my area work together can we hope to see a major improvement in the quality of the water in the local streams and rivers	0.29	0.13	*-0.09*	*-0.14*	**0.51**
7	If you can't see or smell pollution in a river then there isn't a major problem	*-0.32*	0.08	*-0.02*	0.29	**0.37**

Attitude changes amongst CSF project farmers:

Overall, Twrch catchment scored highest for wildlife-awareness, and Deepford was least confident of farmers' ability to improve the environment. Llafar catchment scored highest for 'good farmers know best' and 'it's not farmers' fault' but were also the most positive about cooperation.

During the CSF project farmers' attitudes have changed significantly on all five factors. They have become more wildlife-aware and more positive about the benefits of legislation and cooperation. They have also become more aware of their potential for improving the environment, while their belief that 'good farmers know best' remains strong. They still do not consider environmental issues to be all farmers' fault.

Specific changes in attitude in the CSF catchments between 2006 and 2008:

In Deepford the greatest increase was in wildlife-awareness, followed by increased scores for 'good farmers know best' and 'it's not the farmers' fault'. Their belief in farmers' ability to

make improvements increased significantly, but they ended the project with less faith in legislation and cooperation.

In Llafar attitudes had changed less between the start and end of the project. There was a slight (not significant) decrease in their confidence that 'farmers know best', but they had greater awareness of farmers' responsibility for environmental issues. Although in 2008 they scored slightly less for wildlife-awareness, they were more positive about their ability to improve the environment. They were also significantly more positive about legislation and cooperation at the end of the project.

In Twrch, wildlife-awareness and farmers' attitudes to legislation and cooperative work had improved significantly. They felt more responsibility for the environment (lower scores for 'it's not farmers' fault') and were significantly more aware of their potential to improve the environment (scores for 'farmers can't improve things' were lower).

Respondents in the CSF catchments completing questionnaires in Welsh were less wildlife-aware, less positive about legislation and cooperation but more positive about their ability to improve the environment compared with respondents in the medium of English.

Considering the CSF farmers and public together:

Changes in the farmers' responses can be compared directly with those observed in the public questionnaires. All of the changes noted above were also significant when the public and farmer data were analysed together. Some additional points were highlighted by this part of the analysis:

The more years people have spent in formal education, the higher they score for wildlife-awareness.

Home location is important. Urban respondents were the most wildlife-aware, while people who live in villages scored highest for 'good farmers know best', 'it's not farmers' fault' and 'legislate and cooperate'. Rural people scored highest for 'farmers can't improve things'.

Non-farmers were more wildlife-aware than farmers; amongst farmers, dairy farmers scored highest for all five factors. Farm managers scored higher for 'farmers can't fix it' than farm owners.

Respondents with experience of other agri-environment schemes were significantly more wildlife-aware, felt more strongly that 'good farmers know best' and that environmental problems are not farmers' fault.

Respondents in the public sample who had heard of CSF scored higher on all factors, but only two, ‘good farmers know best’ and ‘legislate and cooperate’, were significant.

Comparison of farmers in the CSF catchments who joined the project, with those that did not join.

The amount of land the farm had within the project catchment may have had an influence. In Deepford and Llafar catchments, farmers who chose not to join CSF had less land in the catchment than those who joined the project (Deepford 46 ha compared with 67 ha; Llafar 142 ha compared with 152 ha). However, in Twrch this was reversed (139 ha compared with 120 ha).

In the 2008 questionnaire, farmers who had not joined the CSF scheme were asked explicitly what their reasons were for the decision. Amongst the potential reasons offered in the questionnaire, the commonest cited was ‘the amount of financial support available under the CSF project wasn’t sufficient to make joining worth my while’ (14 responses), followed by ‘I support the aims of the project but don’t want to take advantage of the technical / financial support offered’ (4 responses).

Most farmers responded ‘other’ (33 in total). This pattern was similar in all three catchments. Some of their specific reasons were:

Deepford:

Not enough land in the catchment. (five farmers)

There was nothing available within the plan related to the farming business (three farmers)

Only land in catchment area is arable, so no need for fencing and no building on this land.

We have done enough capital work over the years to make sure that an effective system is in place to control muck and dirty water on the yard. As the administrative demands are part of the contract we see it as an extra burden (not needed).

Llafar:

I was told that the majority of my farm was outside the plan’s boundaries therefore I wasn’t eligible for a number of things. I was really disappointed with this.

I heard a number of farmers saying that the plan wasn't worth it.

The time of the project was the same as a very difficult time for mountain farming, therefore not a lot of money was available.

Twrch:

Poor period of the business due to low prices

I was eager to join the project especially since most of the land did feed the river but because the farm yard was outside the official boundaries I wasn't allowed to be part of it. I did a lot of useful work testing the soil as well.

I felt that the terms of the grant weren't very clear e.g. when they pay and how. I couldn't get a definite answer from anyone about this. As this was an important part of the decision I decided not to continue.

Differences in farmers' attitudes

Farmers' scores on the five attitude factors can also be used to compare CSF and non-CSF farmers. There has been considerable change in attitudes amongst farmers in the CSF project compared with little change in those who did not join (Table 2.10).

Table 2.10 Farmers scores on the five factors, compared between those who have joined or have not joined the CSF project

		Farmers not in CSF			CSF farmers			(difference between CSF and non-CSF farmers)	
Catchment	Factors	Year			Year			Year	
		2006	2008	(change)	2006	2008	(change)	2006	2008
Deepford	F1 - 'wildlife-awareness'	10.65	10.93	0.28	10.56	10.92	0.37	-0.09	-0.01
	F2 - 'good farmers know best'	16.35	16.96	0.60	16.01	16.03	0.02	-0.35	-0.93
	F3 - 'it's not the farmers' fault'	11.60	12.43	0.83	11.46	11.41	-0.04	-0.14	-1.02
	F4 - 'farmers can't fix it'	5.41	5.07	-0.34	5.73	4.82	-0.91	0.32	-0.25
	F5 - 'legislate and cooperate'	9.07	9.10	0.03	8.78	8.66	-0.13	-0.29	-0.45
Llafar	F1 - 'wildlife-awareness'	10.92	11.05	0.13	11.44	10.98	-0.45	0.52	-0.07
	F2 - 'good farmers know best'	16.39	15.90	-0.49	16.95	16.69	-0.26	0.56	0.79
	F3 - 'it's not the farmers' fault'	11.29	10.84	-0.45	11.95	11.79	-0.16	0.66	0.95
	F4 - 'farmers can't fix it'	5.32	5.02	-0.30	5.07	5.02	-0.06	-0.25	-0.00
	F5 - 'legislate and cooperate'	8.90	8.95	0.05	9.22	9.70	0.47	0.33	0.75
Twrch	F1 - 'wildlife-awareness'	10.75	13.21	2.46	11.74	11.47	-0.27	0.99	-1.74
	F2 - 'good farmers know best'	16.67	17.03	0.35	16.20	16.12	-0.07	-0.48	-0.90
	F3 - 'it's not the farmers' fault'	11.89	11.23	-0.66	10.43	10.58	0.14	-1.45	-0.65
	F4 - 'farmers can't fix it'	5.35	4.02	-1.33	4.79	4.86	0.06	-0.56	0.84
	F5 - 'legislate and cooperate'	8.90	9.91	1.01	8.51	8.76	0.25	-0.39	-1.14
Overall average for F1 - 'wildlife-awareness'		10.78	11.86	1.08	11.14	11.03	-0.11	0.36	-0.83
Overall average for F2 - 'good farmers know bes		16.44	16.54	0.10	16.40	16.35	-0.05	-0.04	-0.18
Overall average for F3 - 'it's not the farmers' fau		11.54	11.30	-0.24	11.42	11.48	0.06	-0.12	0.18
Overall average for F4 - 'farmers can't fix it'		5.36	4.65	-0.72	5.28	4.92	-0.37	-0.08	0.27
Overall average for F5 - 'legislate and cooperate		8.96	9.35	0.38	8.89	9.16	0.27	-0.07	-0.19

Chapter summary

This chapter reports the results of a survey of farmer attitudes in 2006, at the start of the catchment-sensitive farming demonstration project, and in 2008, at its end. In addition, the results of a control survey undertaken in 2006, 2007 and 2008 are reported and used to help interpret the results of the farmer survey.

Both the qualitative and the quantitative analysis suggest that taking part in the CSF project has changed farmers' attitudes in several ways. They have become more wildlife-aware and more positive about the benefits of legislation and cooperation. They have also become more aware of their potential for improving the environment. While farmers' general belief that 'good farmers know best' remains strong, the majority of farmers do not consider environmental issues to be all farmers' fault.

Although some farmers raised some criticisms about the design and administration of the scheme, their overall opinions were very positive. This is evidenced by the large proportion of the farmers surveyed in 2008 who stated that, with hindsight, they are glad that they entered the scheme, and they would be likely to engage in similar initiatives in the future.

CHAPTER 3. STAKEHOLDER ASSESSMENT

Although farmers are key actors in the adoption and implementation of actions that can reduce the risk of pollution, other actors are also involved in, or affected by the CSF project. This chapter reports the views of these stakeholders on the value of the project, its delivery, the cost/benefit of different measures for farm businesses and the lessons learned for future targeted measures.

Note that the body of this chapter represents stakeholders' perceptions of the CSF project, not those of the evaluation team. Interpretation and recommendations from the evaluation team are clearly highlighted as such, and presented under the heading 'Comment'. Direct quotes from stakeholders are included where these were felt to clearly represent a point under discussion.

Some stakeholders' perceptions may not perfectly reflect the intended aims, actual implementation or final results of the project. Such discrepancies highlight a need for clearer communication and project dissemination.

Methods

A brief note about terminology:

The primary aim of this chapter was to gather information about the efficacy of the CSF demonstration project through interviewing stakeholders; either those involved directly with the delivery of the CSF project to farmers, or those invited to be part of steering groups associated with the project. The term 'stakeholder' will be used throughout this chapter to refer to members of either of these two groups. The other key stakeholder group in the project were the farmers targeted by the project; for the purposes of this chapter they have been classified as 'farmers' to differentiate them from the other project stakeholders.

Stakeholder analysis

A list of key stakeholders involved with the project, either directly as functionaries or identified as members of steering groups, was provided by CSF project staff for all the catchments involved (Appendix 6, Table 6.2). Individuals from this list were contacted either by e-mail or telephone; and telephone interviews were arranged following the protocol outlined below. The interviews followed a semi-structured format to allow respondents greater flexibility in their responses than a fully structured interview. A *pro forma* guide was

developed which formed the basis of a structured discussion about the efficacy of the CSF project (see Appendix 6.1).

The *pro forma* was built up around five main elements. Informants were asked to comment on:

(i) The aims and objectives of the Wales Catchment Sensitive Farming demonstration project,

(ii) Communication /dissemination of project findings to the range of stakeholders involved

(iii) Project implementation,

(iv) Project deliverables (both capital works on farms and advice delivered to farmers) during the course of the project

(v) Project monitoring.

Informants were also invited to add further comments should they wish at the end of the main body of the interview.

Interview Protocol

Gwenan Morgan, Assistant Registrar at Bangor University with responsibility for Legal Compliance comprising Data Protection, Freedom of Information, Environmental Information Regulations, Records Management, Ethics, Drugs Precursors and Risk Management; was consulted about the protocol for telephone interviewing. It was noted that a two-stage process was required; first, explaining the nature of survey to informants and describing how information might be used, and second, conducting the interview at an arranged time after the informant has had time to consider the implications.

First stage (arranged either by email or telephone):

The purpose of the survey was explained (i.e. part of an evaluation of the Wales Catchment Sensitive Farming Demonstration Project, aimed at gathering stakeholders' views about the project and its efficacy); and that the results would be summarised in a report to WAG. Informants were asked whether they were willing to take part and if they were willing for their comments to be attributed to them (If not, then it was made clear that only summary information that was not attributable to any specific individual would be used). Once informants were happy with this, arrangements were made for the interview.

Second stage

During the interview, participants were informed when the conversation was being recorded. There was explicit notification when the recorder was switched on at this point; and also that it could be switched off at any time during the interview process. Informants were also given a contact e-mail address should they later wish to add points, or clarify any of their statements.

Results

Aims and Objectives of the CSF project

Relevance of CSF objectives

All stakeholders interviewed were happy that the general aims and objectives of the project were very relevant in Wales, especially given new legislation associated with the Water Framework Directive and the potential for national increases in Nitrate Vulnerable Zones (NVZ).

One of the principal objectives of the project was to develop and test a strategy for mobilising farming communities within the selected catchments to adopt CSF practices. Given the very high take-up of the scheme by farmers this was seen as having been successfully achieved; although there were questions about whether these results could be replicated at a larger scale. Stakeholders, particularly those associated with farmer's unions, were pleased that the project had explored the voluntary (as opposed to regulatory) approach; and felt that the mixture of information and incentives offered by the project was a very appropriate method for engaging farmers.

Comment:- *Farmers might be encouraged to be more pro-active in future CSF projects if they were more involved at early planning stages. For example, discussing CSF principles with them, and offering opportunities for farmers to propose practical solutions.*

As part of the evaluation, stakeholders were asked to comment on how well the concepts associated with agricultural diffuse pollution were understood by the farmers (and other stakeholders) in the catchments. Those stakeholders who had direct contact with farmers felt that there was a good general awareness of the issues surrounding diffuse pollution (if not

the associated terminology). Dairy farmers were more aware of water quality issues in general, but the well-documented issues in both catchments (e.g. toxic algal blooms associated with phosphates in Llyn Tegid), had pre-exposed stakeholders to the issues. However, EAW functionaries who had attended meetings with farmers suggested that many farmers had poorer understanding of subtle and diffuse sources and impacts from their practices:-

"although the majority did appreciate that spreading farm wastes in wet weather was a waste of potential beneficial material".

By the end of the project stakeholders who interacted directly with farmers felt that farmer awareness of issues associated with diffuse pollution had increased.

Scope of CSF objectives

The key project objective was to explore methods of tackling agricultural diffuse pollution. Given that defined remit, all stakeholders interviewed were content with the scope of the objectives. There were comments from stakeholders (in CCW and APCE) that the term 'catchment-sensitive farming' encompassed more than just diffuse pollution (specifically, more than yard works); that the demonstration project and any future projects should be broader in scope, to include the whole issue of on-farm water management. In future projects these stakeholders would like to see more integration of other elements associated with catchment health; including drainage management, biodiversity issues and flood risk.

The work done in exploring approaches for engaging farmers in tackling diffuse pollution was widely valued.

The source of funding for the project (Objective 1 funding from Europe) had a big impact on what could be offered to farmers. In particular, no land management agreements could be made with farmers. CCW staff considered this to severely limit what could be achieved in reducing diffuse pollution from farm yards (95% of the money received by farmers was spent on capital works on-farm). They considered that a holistic approach to tackling diffuse pollution would require land management change, although the soil audits were considered a 'cheap but effective' tool.

There was a general consensus that the scale of the demonstration project was sensible – and that operating at the whole-catchment scale was very appropriate and likely to yield positive results.

Project Planning and Communication

Project planning

All stakeholders were aware of the aims and objectives of the project and felt that these had been communicated clearly by project staff at the outset of the project.

Whilst most stakeholders were happy with the catchments chosen for the demonstration project, some commented that they had not been given clear information on why these catchments had been chosen.

There were mixed feelings about the level of communication between stakeholders during the course of the project. Initial communication between the key agencies (WAG, EAW, CCW and APCE) was handled very well by project staff. Once the project was running this communication became much less frequent, and stakeholders from EAW and CCW felt that that many of the interactions (from WAG staff) were infrequent or 'last-minute' and therefore difficult to respond to.

"There were missed opportunities for updates, understanding progress and findings of the different work areas during the life of the project".

Stakeholders considered that the two project steering group meetings had a limited range of participants; which was felt to limit the input these agencies could make once the project was running. One stakeholder noted that other potentially-interested parties (particularly NGOs like the RSPB and representatives from the water industry) were not invited to be part of the steering group. In future projects it might be valuable to expand the steering group to incorporate these stakeholders, and to have more regular meetings throughout the project lifespan.

Communication between stakeholders and the modelling group was felt to have been poor. Very few of the stakeholders mentioned the work done by the modelling group at all. Those stakeholders with potential to impact the modelling work (EAW) noted that their contact with ExCal (the project modellers) had been minimal – with little apparent interest (from ExCal) in the data EAW were collecting until the project was partway through.

"If monitoring work had been more closely linked to ExCal work at the outset it would have benefited both parties – ensure these are done by one organisation in future schemes?"

Project dissemination

Communication between farmers and project staff was considered to have gone very well by all stakeholders. This was identified as a major positive factor in generating and maintaining interest in the project by farmers within the catchments (and beyond). Stakeholders involved with farmer extension work and farmers' unions, reported that feedback to them from farmers had been almost universally positive (and where it was not this had been due to not being able to be involved with the scheme). From their experience of other projects, they felt that any problems would have been brought up with them quickly and were surprised that there had been so little negative feedback.

The project was introduced to farmers initially through local kick-off meetings (to which all farmers within the target catchments were invited). There was a high turnout at all these meetings and they were considered very successful in setting out what the project was about. A high proportion of farmers who attended these meetings returned registrations of interest to the project staff.

Project staff also conducted a number of farm visits with all interested farmers. The aim of these was to agree appropriate interventions on the farms. This element was viewed very positively by stakeholders.

"Project officers have been very helpful. It was critically important that staff were approachable and could talk on farming terms. Also [it was good] that they were prepared to walk around farms and get their hands dirty".

Catchment officers played a critical role in the assessment of farms within the catchments, and in building trust and encouraging farmers to engage with the project.

Information was also communicated to farmers through demonstration days held on the farms. These were viewed positively by stakeholders – but many felt that it would have been helpful if there had been more demonstration days throughout the course of the project. There was generally a lower turnout to these meetings (than the evening meetings); largely due to their timing (as farmers often had other commitments during the day). A couple of issues associated with this were highlighted by stakeholders:

(i) In the Llyn Tegid sites farmers complained when both the guest speakers at one event communicated everything solely in English.

(ii) Stakeholders from the farming unions and farming extension workers felt that the demonstration days were a missed opportunity to communicate more widely to farmers outside the project area - especially with regard to promoting more easily applicable ideas such as general nutrient management.

Given the short duration of the project, stakeholders were aware of the limitations in what could be achieved through demonstrations; but this was still identified as a very important element for farmer engagement.

"It would have been helpful if more farmers could have visited farms where capital works had been installed – even visit farms elsewhere in the UK"

In addition EAW staff commented that they had other ideas for demonstration days that would have been helpful to get their points across (such as live invertebrates sampling/trays of invertebrates– which were successful on other projects (e.g. Bathing water Diffuse Pollution Project) and should be included in future.

Comment:- *Farmers value the opportunity to see things working, and demonstration farms with installed capital works improvements are effective communications tools. Potential difficulties were noted in predicting the number of visitors to demonstration events, particularly if they were open to farmers outside the catchments. These might be addressed through direct feedback: planners could advertise to farmers and ask for a statement of interest if they were likely to come; for the most popular events a number of open days rather than single days could be offered.*

During the course of the pilot scheme, information about the project was disseminated to farmers involved directly with the project through quarterly newsletters. The newsletters contained information such as how many farmers had got involved with the scheme; and also contained short articles on topics such as nutrient management planning. Stakeholders were generally very positive about the newsletters. Both the length and content was felt to be appropriate for the target audience, and quarterly updates were appropriate for maintaining interest.

The newsletter was identified as the main method by which most stakeholders heard about what was happening in the other catchments. This was viewed as adequate although some members of the steering groups felt that having a report targeted specifically at steering groups (with additional information to the newsletter that was targeted at farmers) would have been helpful for them in monitoring the overall progress of the project.

Project officers shared information with each other about progress in the catchments using monthly video conferences. This was considered a very efficient method for communicating progress.

Project staff commented on the need to hold final workshops with farmers to inform them on progress.

Comment: *These occurred in September 2008 in all catchments.*

Awareness about other CSF demonstration sites in the UK

Many stakeholders, including some project functionaries, had only limited awareness of other CSF work conducted elsewhere in the UK.

In contrast, EAW staff were clearly aware of other planned or ongoing projects with parallel aims to CSF; in consequence there was a feeling amongst EAW staff that the scientific case for the capital works element of the CSF project had largely already been made in terms of benefits to water quality (although not in Wales). Other stakeholders who were aware of CSF projects elsewhere in the UK also felt that the main thrust of the project (the use of capital works to reduce diffuse pollution) had already been established.

"There was little need to pilot this as the concept was already well understood (from CSF work elsewhere in the UK)"

WAG Project officers had visited CSF sites in Scotland and England prior to the start of the project and identified this as very helpful.

It was felt that better dissemination about these projects to both the farmers and other stakeholders would have been helpful. There was also the suggestion that taking farmers to see sites elsewhere in the UK may have been helpful in the early stages of the project (given the constraints in getting capital works established within the project time frame).

Wider dissemination:

A number of stakeholders felt that there could have been wider communication about the project to both the farming community and other stakeholders impacted by water quality issues. There was limited national output from the project, including articles in G*wlad.*

They felt that it would have been helpful and appropriate to include more information about the project in technical journals (such as Farmers Weekly).

For future projects it would also be helpful to work with appropriate farmers to encourage and assist them to host farm visits; to farms where capital works had been implemented, to

allow farmers from outside the catchments with an interest in CSF to see what was happening.

It was also noted that the project:

"… missed opportunities to raise awareness of CSF to residents living by Bala lake where the impacts of phosphate loading had severely reduced water quality on the lake."

Implementation

Contact between project staff and farmers

Stakeholders identified the possibility of tensions between farmers and project staff at the start of the project; particularly those project staff working for the EAW and WAG - who are often viewed suspiciously by farmers because of their regulatory capacity. It was widely felt that the project staff had been careful in how they approached farmers, emphasising that they were present in a non-regulatory capacity and this had worked very well. On the other hand there was the feeling that:

"…there seemed to be an almost excessive fear that EAW presence at the farm evaluation phase would have an adverse affect on take up of the scheme".

Many of the project staff had experience of working in the target catchments on other projects prior to the CSF project. This allowed them to build upon established relationships. Key farmers in the catchments (i.e. those known by project staff or to members of the stakeholder groups to be interested and pro-active) were deliberately targeted in the first phase of the project.

Having key farmers leading activities was seen by project staff as a critical element in bringing the more hesitant farmers into the pilot.

In both catchments the biggest take-up was by farmers already within the *Tir Gofal* agri-environmental schemes – these farmers were considered "*much more switched on*" and were quicker to take advantage of the capital works.

The Deepford Brook catchment also included a number of important farming figures including the current chair of the Agri-food Partnership and senior members of the Farmer's Unions. This was beneficial in getting things running.

"The selection of the catchment for the pilot was very good in terms of compliant farmers".

In Llyn Tegid the farmers were described as "*quite traditional farmers – set in their ways*"; however, many were already in *Tir Gofal*. Some interviewees suggested it would have been easier in this catchment if the CSF objectives could have been incorporated into the agri-environment scheme – especially as *Tir Gofal* agreements could potentially interact with several elements of the work (i.e. fencing, roofing).

Comment:- *Few stakeholders had any background information on how the catchments were chosen or how future catchments might be targeted. Comments on the integration of CSF elements into Tir Gofal included the point that linking the funding available under CSF to an agri-environment scheme might benefit both schemes; rewarding participants and making the rest of the scheme more attractive to non-participants.*

A number of stakeholders made the point that with the generous level of grant aid on offer it was always likely that farmers were going to be interested – particularly the dairy farmers who would always be interested in capital works. In contrast, the current state of beef farming in Wales meant that this group were much more hesitant about investing in capital works – since many would be unlikely to see a return on their investment. Stakeholders were keen that the reasons for the low uptake of some capital works was clearly documented, and that the implications of this were taken forward.

Comment:- *Note that few or no stakeholders had complete information on why the grant-rate was set at 60 %. All participants in this survey compared the CSF grant-rate with previous 'successful' and 'significantly cheaper' projects such as Farming Connect; many equating the high level of farmer uptake with the (apparently) generous capital grants. There was concern about the sustainability of this high grant-rate in any future CSF projects.*

Stakeholders' concerns about the sustainability of 60% grant aid led to considerable discussion on how future projects should prioritise grant aid. Soil nutrient testing was a very successful example of CSF providing information to highlight a potential problem and the farmers responding appropriately; many stakeholders felt it highlighted a need for advice provision that might be a better use of public money than high capital investment. This discussion may identify a communications gap: stakeholders did not seem to appreciate fully that CSF, strictly speaking, did not fund the provision of advice to farmers.

Informed staff noted there had been some bottlenecks in processing large numbers of applications received in a short time. Other stakeholders felt that the project

"suffered from a lack of forward planning, particularly with regard to statutory processes associated with capital works (for example planning permission and EAW commissioning of slurry pits)"

There was a hiatus after the kick-off meetings, as farmers were left to come forward at their own speed. This created an initial lull at the beginning of the project which then had a knock-on effect on the project timetable. This was mentioned as something that could have been dealt with more pro-actively. However once farmers responded the project staff were generally felt to be very efficient in processing applications.

Comment:- *For budgetary reasons, an incentive was offered for capital works completed by the end of December 2006. Although all capital works were complete within the project timeframe many were only completed towards the end of the second year.*

The EU requirement for three quotes was considered an impediment to initial progress. The nature of the catchments meant that there were a limited number of contractors potentially available to give quotes (and do the work); especially within the project time frame. The project also insisted that works were up to British standard, which created some problems with some contractors who were unaware of those standards! The project applied to the EU to alter the requirement, but this took at least six months and had an impact on the early progress of the project.

CSF Project works

The general consensus from the stakeholders was that the farmers were happy with the choice of measures offered, and that the project had been a positive learning experience for farmers.

The farmers also had an opportunity to make suggestions to project staff and these were taken on board. For example the farmers in Llyn Tegid raised the issue of liming with project staff and this was taken forward into the project.

There were several options that stakeholders would like to have seen incorporated into future projects, including:

(i) Exploration of the use of reed beds on farms; although there was also acknowledgement of associated regulatory issues such as farmers requiring consent to discharge.

(ii) Further options for sheep dipping – including exploring the use of green paddocks for safely containing recently dipped sheep.

There was some disagreement between stakeholders about the balance of field work and yard work within CSF.

"Farmers like to do their yards – and they were given what they wanted"

Stakeholders from the EAW and the farmer's unions were happy with the focus on yard works (where the bulk of the money was spent), whereas stakeholders from CCW were concerned that these options did not target the main source of the problem (but acknowledged that restrictions imposed by funding reduced the possible options). Indeed, members of the farming unions felt that the amounts of money available for farmers were correct (and could even be improved); and that this should have been the primary emphasis of the pilot project.

Stakeholders commented that soil testing was very popular with all the farmers, often giving results that surprised them. This element of the project was felt to be very helpful in raising awareness (of diffuse pollution), and also improving understanding about underlying issues; at a relatively low project cost. However,

"The increase in the price of fertiliser may well have a bigger impact on water quality then the scheme itself"

It was felt that although the interventions and suggested changes of practice were undertaken to benefit water quality and carried no direct farm business benefits, many also offered incidental or wider benefits to the farmer such as reduced labour, cleaner yards, increased animal health through better drinking water and reduced worry over potential pollution incidents. Explaining these collateral and potential benefits to farmers was seen as a very important element of the project. Respondents gave anecdotal evidence of farmers adapting their practice; but also raised issues with project monitoring and whether this type of 'soft' project output would be recorded by project staff (see relevant report section below).

Most stakeholders felt that a major benefit of CSF was that it included both a specific farm audit to highlight pollution issues, and a high level of grant to allow farmers to engage with these issues. This differentiated it from many other projects tackling similar issues.

The two sites differed in terms of the number and types of options taken up:

In Deepford Brook there was a high take-up of yard improvements, but the field elements were less popular (with the exception of soil testing).

In Bala the soil sampling was very popular but, possibly because farmers were concerned about getting a return on their investments, capital works uptake was not as high.

Stakeholders felt that having clear information on the reasons behind these differences was important. Those stakeholders who were not in direct contact with farmers were unclear about the reasons why farmers in the different catchments did not take up certain options. There were questions about the extent to which this had been explored and reported by project staff – as this had not been reported on to date.

Constraints to farmer take-up of CSF options

Stakeholders suggested a number of reasons why farmers did not take up particular CSF options. The major points are outlined below:

(i) Difficulties in meeting EAW regulations for structures. Farmers found some specifications overly prohibitive; the example given was storage tanks – the size of tank dictated by EAW M48 was too large for many farm yards, and this prevented many farmers from choosing this option.

(ii) Farmers' concern about future legislation. The example given for this was sheep dipping. During the course of the project some sheep dip products were taken off the market, and there were concerns (by farmers) that the practice could be banned. As a result, many did not want to invest in new dipping facilities; preferring to carry on using outside contractors – which is recognised as generally more hazardous for water quality.

(iii) Wider economic factors. In Bala there was a much more limited uptake of capital works partly due to the nature of the farming enterprises, and farmers' concerns about the future. Many farmers were concerned they would not get a return on their investments – especially with the current state of beef farming.

The role of project officers

Stakeholders were very positive about the use of local project officers with responsibility for 'everything' related to the project in their area. Feedback from farmers indicated they were

happier dealing with a single individual rather than a range of project staff. The ratio of project officers to farmer was very good.

The project officers' responsibilities also included a large amount of internal bureaucracy (due to the nature of the project), which apparently limited the time they had available to talk to farmers. This was felt to be something that should be minimised in future projects

Some concerns were raised about the role played by project officers in prioritising or (potentially) influencing works on farms. The CSF pilot was felt to require:

"a full appraisal of the catchment to identify areas of high risk to allow sensible targeting of investment prior to approaching farmers"

Project functionaries stated that work had been done on this initially, but that

"Very little was written down about this element of the project and passed on to stakeholders."

Stakeholders suggested that the onus was then heavily on project officers; particularly their individual ability to assess the catchments and target key farmers for work on the basis of potential risk. Questions were raised about whether Catchment Officers were able to prioritise farms, especially given the wide menu of options they had, and the influence of farmers' preferences. WAG staff admitted that due to the voluntary nature of farmers' involvement, those that were keen to sign up were generally dealt with first – although sub-catchments were targeted for visits.

Similar concerns were raised about whether the options taken up by farmers were the most appropriate intervention on the farm; with the final decision being dependent on the project officer's ability to appraise a farm and come to an agreement with farmers as to the most appropriate intervention. There was a feeling amongst some stakeholders that in some cases things were

"…possibly too much in the farmers' hands and (there was) too low a level of guidance from project officers".

A number of stakeholders felt this view was supported by their visits to farms, where they noted evidence of infrastructure on-site that was still causing a problem *after* capital works had been completed – including effluent leaks clearly visible from old structures (which could have been repaired very cheaply), and fields tied into nutrient plans where there were clearly no productive grasses.

Even given these reservations, the use of 'local' project officers was considered critical to the success of future projects. Maximising their ability to work closely with farmers (as opposed to bureaucracy) was seen as a future priority. It was also noted that having project officers

drawn from a broader range of experience would be helpful for incorporating a range of water issues in future projects.

Project monitoring and Project Outputs

Stakeholders felt that monitoring was important to the success and future relevance of the CSF pilot study:

"The CSF project needs to provide clear guidance for future schemes on which elements of the project were most efficient (i.e. provide greatest returns in improved water quality as well as value for money)"

"Important message for Water Framework Directive – with risk-based approach to monitoring and programme of measures, there is a risk that anything we are confident is at high or good status will be ignored That is, this project has shown there are still issues (e.g. Phosphate and solids sources) even if the impact is further downstream. We need to remember this and look further upstream of problem water-bodies as part of investigations"

Water quality monitoring

A number of concerns were raised by stakeholders about the level and content of the water quality monitoring during the course of the demonstration project.

A number of stakeholders described the water quality monitoring as very limited. EAW respondents were aware from the outset that it would be

"difficult to demonstrate immediate environmental impact improvements and this was communicated to WAG project staff (especially with regard to the reaction of farmers)."

The lack of baseline monitoring data for the catchments was identified as a failing of the water quality monitoring component. This was compounded by the fact that the capital works took longer then expected to implement and that

"…we would have been better off doing more intensive sampling (for a two year period) at the end of the project"

There was a general feeling that two years of water quality data were unlikely to show significant water quality improvements, especially as improvements in diffuse pollution will take time to emerge due to soil buffering.

"…essentially the project produced a snapshot of the water quality in the catchments"

But

"There was more sampling than would be required for the WFD but not enough for a proper scientific evaluation."

Monitoring effort was considered to be too small to pick up changes and needed to be more strategic in approach.

"Sampling appeared to be quite ad hoc".

"Did the water quality monitoring directly address the CSF objectives?".

Some stakeholders felt they had been given very little information about the extent of the monitoring by EAW. Overall, the general expectation was that that the monitoring would not meet the high scientific standard needed to allow a proper evaluation.

This negative view of water quality monitoring was countered by project staff (and CCW) who stated that the water quality monitoring had never been intended to be effective at research level; but was really designed to provide information for farmers.

"In order to get the detailed output about the effect of improvements would have required a prohibitively large amount of the project funding to go on monitoring"

Catchment modelling was identified as a very important element of this pilot, as it was in place to meet the acknowledged shortfalls of the monitoring work. However, few stakeholders mentioned it, or appeared to be aware of progress within the modelling component of the project.

Selection of CSF pilot catchments

Some respondents commented that water quality in the selected catchments "*was not very bad to begin with*" and that it might have been more appropriate for the demonstration to have targeted at least one catchment with a bigger water quality problem. They felt that this would have made it easier to show 'visible' benefits of any of the works implemented.

Comment:- *Fair and effective resource allocation for water quality improvements at national and local scales is a complex issue and a matter of considerable current research. In the absence of adequate tools for such prioritisation, the project design avoids discrimination between farms by inviting participation from the whole catchment.*

Once the catchments themselves had been selected, all farms with land / yards within that catchment were equally entitled to join the scheme and apply for grant aid; the scheme allowing any works designed to mitigate pollution. Project officers used farm inspections to identify a set of permissible (within CSF) interventions on each farm; the farmer then discussed possible options with the project officer, before selecting any (or all) of them up to the grant limit (and farmers' contribution budget).However, if an individual farmer refused to tackle a major source of pollution identified during the farm inspection, Catchment Officers were instructed to withdraw from negotiations.

The strong element of individual farmers' choice was identified as both a strength and a weakness of the project. Farmers' priorities are not necessarily in line with water quality priorities, and they were free to choose (potentially) less optimal works that offered better collateral benefits if they so wished. Here, the role of the Catchment Officer is once more central to the effectiveness of the project since he/she is in a position to negotiate with the farmer.

If the pollution risk posed by all the suggested options could be objectively assessed, it might be possible to offer different levels of grant aid (e.g. 40% to 100%) based on an assessment of pollution risks, cost (actual and farm practice costs) and any collateral benefits to the farmer. However, any formal prioritisation process would have to be absolutely transparent and documented.

Cross-compliance

Some stakeholders raised the issue of how grant-aid offered under CSF was integrated into cross-compliance:

> *"The project was not clear on this. Were farmers paid to achieve minimum rates of compliance?"*

***Comment:-** an absolute requirement in designing any agri-environment scheme is that all applicants submit to cross-compliance regulations. In CSF, farmers did not receive payments for work required by cross-compliance. The stakeholders' concern highlights the importance of communicating this fundamental assumption, not just to the target farmers but also amongst wider stakeholders.*

Other monitoring

Stakeholders who took advantage of the farm diaries widely considered them a very useful resource, potentially offering new insights into farmer behaviour. However, some respondents either did not realise they were available or did not request access to the diaries; although they noted that this type of information would have been very helpful for event-based modelling.

Exploring farmer attitudes was considered to be a very important element. There was considerable interest in the assessment of changes in practices – but stakeholders noted some uncertainty about whether this assessment had been included in the project. It was suggested that the monitoring period might be too short to pick up changes in farming practice, and that:

"It would have been good to revisit the farms in a couple of years' time to see if practice had changed (which is not currently a project task)"

Finally, concerns were raised about monitoring and signing-off grant-aided capital works. Was monitoring conducted to see if old structures were removed?

Chapter summary

Twenty-one stakeholders form public and private organisations were interviewed, using a semi-structured interview technique, in the summer of 2008. The main topics covered in the discussions included the aims and objectives of the demonstration project; communication /dissemination of the project; project implementation, project deliverables and project monitoring.

There was a general feeling of satisfaction with the scope of the demonstration project and its scale of operation. Communication with farmers in the demonstration catchments was felt to have been good; but there were some suggestions as to how communications with other farmers in Wales could have been enhanced. Stakeholders were generally content with the design and operation of the demonstration project; however, a range of minor criticisms were made, and several stakeholders felt that improvements could be made in future implementations of any catchment-based schemes. Some of the concerns raised by wider stakeholders could be allayed by more transparency in the farm-level decision making process and a clearer presentation of funding requirements and constraints. A fuller discussion of the advantages and disadvantages of some of these suggestions (i.e. grant rates, targeting, cross-compliance) is given in Chapter 6.

Several stakeholders had expected more intensive monitoring - that could have offered solid evidence as to the success (or otherwise) of the demonstration scheme. There was widespread disappointment that this had proved impossible. However, some of the stakeholders recognised that catchment modelling largely took the place of rigorous monitoring in this pilot project. The issues surrounding the theory and practicalities of water quality monitoring are further discussed in Chapters 4 and 6.

CHAPTER 4. EVALUATION OF WATER QUALITY MONITORING DATA

A number of aspirational tasks were assembled in this work-package (Table 4.1) under the assumption that the availability and quality of water quality (WQ) monitoring data for the pilot catchments (both historic and contemporary as part of the CSF pilot study) were much greater than proved to be the case. Indeed it became necessary for the contractors (ExCal) engaged on the CSF modelling contract to undertake their own hydrological measurements and water quality sampling in order to parameterise their model. This measurement programme was discussed within the CSF Catchment Modelling Steering Group and has subsequently been implemented by ExCal.

Table 4.1. Tasks to be undertaken as part of Data Evaluation work-package. Tasks are presented in the chronological order in which they were planned to occur.

No.	Task
1	Identify water quality data available from earlier studies
2	Set up data base for current and earlier data utilising CEH Oracle-based Integrated Data System
3	Establish protocols for provision of EA WQ data from CSF demonstration project to CEH / Bangor University
4	Collate all available WQ monitoring data from spot samples and continuous monitoring
5	Identify (with EA and local field staff) possible sources of nutrients and sediments within the catchments not associated with agricultural activities; and the data available to describe them
6	Assemble data on river flow and rainfall as factors influencing interpretation of WQ data
7	With local catchment staff, assemble information on farming practices and other management activities likely to influence interpretation of WQ data
8	Undertake analysis of WQ data using simple visualisation - time series plots, spatial mapping. Use the initial analysis to identify anomalous points, modify data sets if necessay
9	Depending on the outcome of 8, undertake more detailed analysis of spatial and temporal patterns in WQ data, for example in relation to river flows, antecedent conditions etc.
10	Combine analysis of 8 & 9 with assessment of model predictions from contract 105/2005

In the light of these developments, this section of the report has been re-organised to address more generic questions which will hopefully benefit future CSF projects. Essentially, this chapter can now be considered as a 'lessons learned' assessment. The Tasks described in Table 4.1 are addressed in the following revised structure:

4.1 What were the perceived WQ problem in each catchment?

4.2 Are the monitoring programmes adequate to capture the likely benefits of CSF remedial works? (Tasks 1-4 in Table 4.1)

4.3 What confounding factors will affect the interpretation of the WQ benefits of CSF?

- 4.3.1 Small point sources of pollution (Task 5 in Table 4.1)
- 4.3.2 Rainfall and run-off (Task 6 in Table 4.1)
- 4.3.3 Plantation forestry
- 4.3.4 Sewage treatment works

4.4 Were the soil chemical analyses undertaken for the CSF pilot project appropriate for water quality assessment? (Task 7 in Table 4.1)

4.5 Comments on the design of WQ monitoring programmes for CSF projects (Tasks 8 and 9 in Table 4.1)

4.1 Perceived water quality problems in each catchment

4.1.1 Tegid catchments

Since the toxic algal bloom of 1995, there has been a significant body of research conducted under the auspices of the Llyn Tegid Environmental Panel into the causes of eutrophication in Llyn Tegid. A number of potential sources of nutrients have been identified within the Tegid catchment including sewage treatment works (STWs), private sewage treatment systems (PSTSs) and diffuse pollution from agricultural land and plantation forestry.

In a detailed piece of work, Millband *et al.*, (2004) concluded that diffuse sources of nutrients accounted for over 90% of the total phosphorus entering the lake annually. The remainder comprised inputs from point sources including four small sewage works. The study identified the main sources of diffuse phosphorus to Llyn Tegid as improved pasture and channel bank erosion. The pre-dominant agricultural land use is sheep grazing on improved and unimproved grassland.

4.1.2 Deepford Brook

In the Deepford Brook catchment which supports intensive dairy farming, nitrogen enrichment and suppression of dissolved oxygen (DO) are the main diffuse pollution issues. Schofield *et al.* (1990) concluded that dairy farming activities such as yard and milking parlour washing, slurry wash-off and the pattern of rainfall in relation to these activities were the major influences on ammoniacal-N and DO fluctuations in ditches and tributaries feeding Deepford Brook. The most intense effects of farm pollution were observed in the small tributaries directly receiving drainage from the farms. An effect was observed in Deepford

Brook downstream of the main pollution input, but dilution was an important factor attenuating the signal (Schofield *et al.*, 1990).

4.2 Evaluation of WQ monitoring programmes

4.2.1 Tegid catchments

Data from the Environment Agency (EA) were provided to the Evaluation Project by ExCal. Routine samples were collected from two sites in each catchment at approximately monthly intervals, although more frequent samples were occasionally included in the data. The data provided to the evaluation project covered the period from August 2005 to September 2007.

High flow 'event' sampling was undertaken on two occasions (May and August 2006) from the lowest sampling sites in each of the Llafar and Twrch catchments and on one occasion (August 2006) from two further points on the Llafar (the Afon Dylo tributary and the main stream at Rhyd yr Efail). The event samples were collected at 30 minute intervals using automatic equipment

The primary focus of the CSF project was on nutrients (N & P) and suspended sediments; Table 4.2 shows the suite of relevant determinands that have been measured by the EA.

Table 4.2. Descriptions, codes and reported detection limits for determinands measured in the Tegid catchments.

Determinand name (units)	Reported detection limit
Ammonia as N (mg l^{-1})	< 0.03
Nitrogen Total Oxidised as N (mg l^{-1})	< 0.2
Nitrate as N (Calculated) (mg l^{-1})	< 0.196
Nitrite as N (mg l^{-1})	< 0.004
Solids Suspended @105C (mg l^{-1})	< 3
Orthophosphate as P (mg l^{-1})	< 0.02
Phosphate (mg l^{-1})	< 0.5
Orthophosphate (µg l^{-1})	<1.5 (< 0.0015 mg l^{-1})
Phosphate (µg l^{-1})	< 20 (< 0.02 mg l^{-1})

One of the main features of the river WQ data was the large numbers of 'less than' values, i.e. values reported as being below the detection limit of the analytical method used (Table 4.3). For example, upwards of 60% of the orthophosphate and suspended sediment data from the routine sampling were reported as below the detection limit for the Twrch and Llafar lower sites. This makes it difficult to interpret the data and to identify potentially subtle WQ

changes in response to the CSF management interventions. In contrast, the storm event data have a 100% record of valid data for these determinands at both sites for each event.

Table 4.3. Percentage of valid measurements, less than values and missing data for suspended sediments and orthophosphate in the Twrch and Llafar for the two year sampling period.

Twrch site 202	**Suspended sediments**	**Orthophosphate**
Less than values (%)	75	63
Missing data (%)	10	23
Valid measurements (%)	15	15
Llafar site 209	Suspended sediments	Orthophosphate
Less than values (%)	61	59
Missing data (%)	24	27
Valid measurements (%)	14	14

'Less than' values may be indicative of good water quality but may also be due to the use of inappropriate analytical methods for the type of waters encountered in the Twrch and Llafar catchments. These catchments have an upland character, and would be naturally of low nutrient status; particularly in the upper reaches. More sensitive methods for the determination of nitrogen and phosphorus species are therefore required. Whilst conventions exist for the statistical treatment of 'less than' values in WQ time series data, large numbers of these values clearly undermines the value of the data. The need for more sensitive analyses was recognised in the early part of the study; and also for the event sampling, where data coverage is better. The analytical methods were perfectly adequate for the STW effluent samples where nutrient concentrations are much higher.

The study by Millband *et al.* (2004) highlighted the importance of event sampling for the fluvial transport of sediments and phosphorus in the Twrch and Llafar catchments. This was confirmed by the event sampling reported for spring and late summer 2006 for the CSF project (Figure 4.1). Regular sampling is generally poor at capturing storm events in flashy headwater streams because flow responds rapidly to rainfall and the events themselves may be relatively short-lived (see e.g. Figure 4.1). The bias in the routine sampling programme towards low flows may have contributed to the large number of reported less than values as concentrations of suspended sediments and phosphorus will tend to be low in these streams if point source inputs are absent.

Although event sampling is logistically difficult and time consuming, even with automated equipment, the nature of the diffuse pollution problems in the Twrch and Llafar means that it

is a potentially important tool for detecting WQ responses to the CSF management interventions.

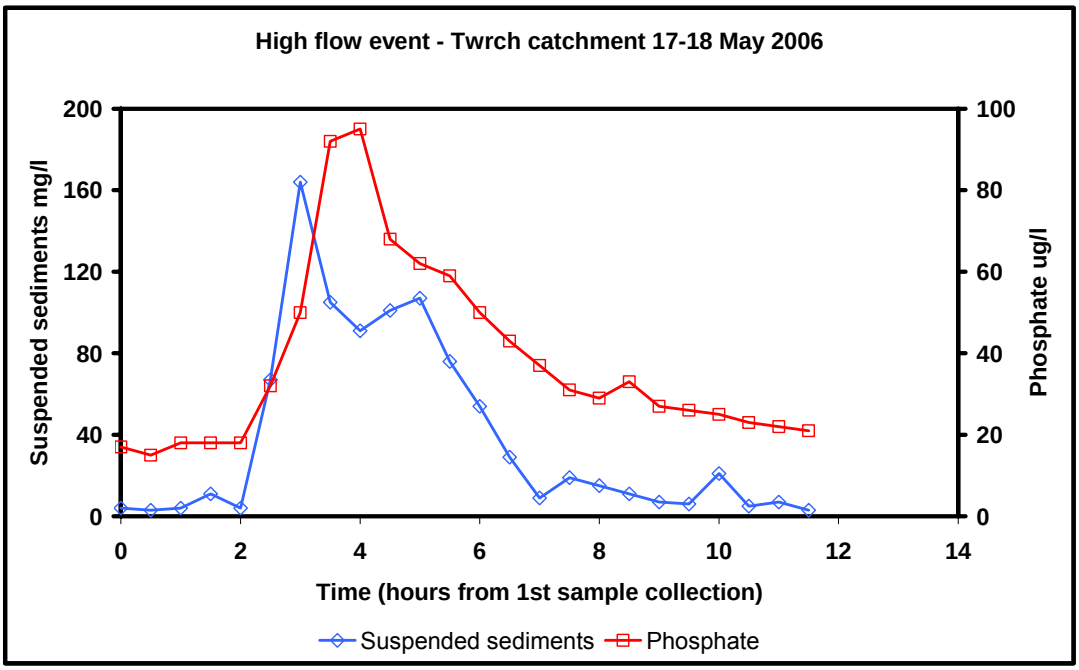


Figure 4.1. Variations in suspended sediment and phosphate concentrations through a high flow event in the Twrch catchment sampled on 17th-18th May 2006. Data from Environment Agency Wales.

Continuous measurement of WQ parameters is a viable alternative to event sampling and a number of probes and sondes are routinely deployed for monitoring dissolved oxygen, turbidity, pH, ammonia and conductivity. New developments in chemical monitoring equipment mean that continuous measurements (ie at intervals of an hour or less) of soluble reactive P, Total P and nitrate are also possible especially at sites with mains power. The equipment uses 'wet chemistry' techniques, stores the data on loggers and can be purchased for £20k to £30k. The instruments require careful maintenance, but will provide data at times rarely covered by conventional sampling programmes such as through the hours of darkness and high flow events.

4.2.2 Deepford Brook

Routine spot samples were collected at approximately monthly intervals from six sites in the Deepford Brook catchment. Data were provided from September 2005 to December 2007 and the range of analytes measured (Table 4.4) was similar to those in the Llafar and Twrch catchments.

Overall the data from the Deepford Brook spot sampling sites have fewer 'less than' values compared to the Tegid data reflecting higher concentrations of nitrogen in particular. Detection limits for the determination of phosphate were also reduced from < 0.5 to <0.02 mg l-1 after June 2006.

Table 4.4. Descriptions and reported detection limits for determinands measured at Deepford Brook.

Determinand name (units)	Reported detection limit
Ammonia as N (mg l^{-1})	< 0.03
Nitrogen Total Oxidised as N (mg l^{-1})	< 0.2
Nitrogen Total as N (mg l^{-1})	No LT values reported
Solids Suspended @105C (mg l^{-1})	< 3
Orthophosphate as P (mg l^{-1})	< 0.02
Phosphate (mg l^{-1})	< 0.5 pre 06/06; < 0.02 subsequently
Oxygen dissolved as % saturation	N/A
Oxygen dissolved as concentration (mg l^{-1})	No LT values reported

Dissolved Oxygen (% saturation and concentration), pH, ammonia, temperature, conductivity and turbidity were monitored continuously at three sites during the summer of 2006 (June to September) from three sites (Figure 4.2).

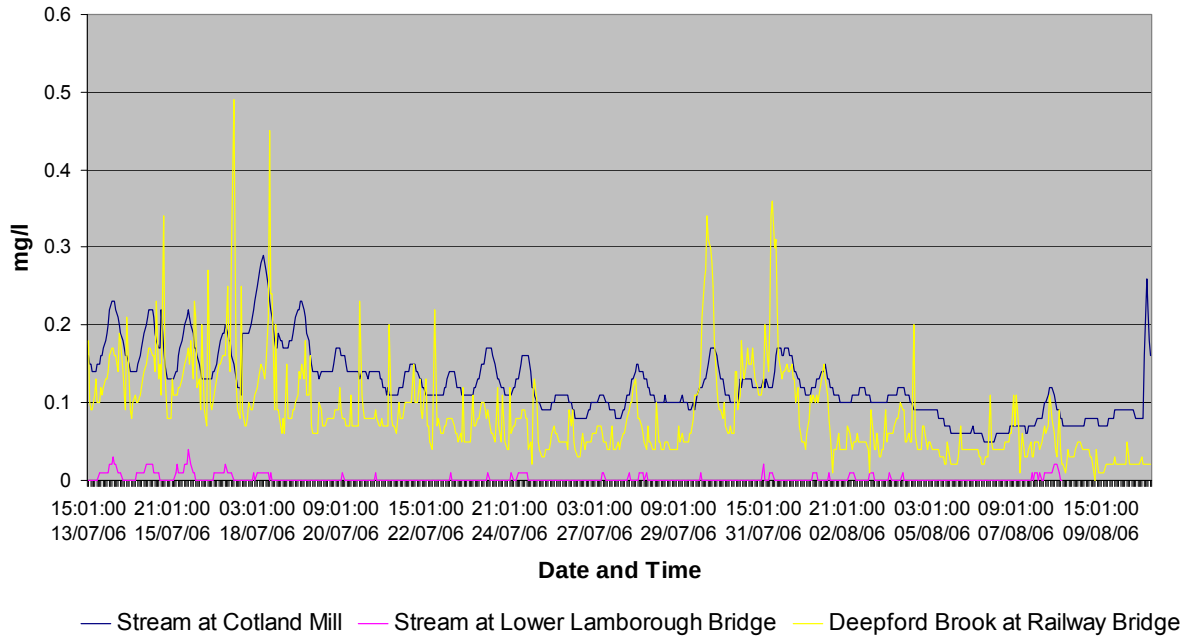


Figure 4.2. Continuous ammonia data from Deepford Brook (from EA 2007)

The continuous monitoring data are limited to a single summer period but show that ammonia concentrations were quite different between the three sites. The data highlight

some individual events of high nutrient (ammonia) concentrations (Figure 4.2) which may well relate to wash-off of pollutant material during rainfall events. The data illustrate the value of continuous monitoring for capturing short-lived but potentially significant 'events' and could usefully be extended temporally and spatially to include the ditches at Stubbleborough Farm and Lower Lamborough as suggested by Schofield *et al.* (1990).

A summary report of the WQ data for the CSF project was produced by EA staff in February 2007 (EA 2007) and was made available to the evaluation project. The report identified that the more ecologically relevant forms of nitrogen and and phosphorus were not measured initially, but this was rectified as data for notal oxidised nitrogen and orthophosphate were presented from April 2007 onwards.

The EA report concluded that nutrient concentrations generally increase downstream in Deepford Brook with distance from the headwater sampling point at the Railway Bridge. With the exceptions of DO and nitrogen, the additional data to December 2007 confirm this pattern. The report also concluded that DO concentrations were not a cause for concern although there were identifiable sediment sources within the catchment. The report noted that there were too few data (as of February 2007) to draw firm conclusions. The additional 6 months of data supplied to ExCal and the Evaluation Project confirmed the EA report conclusions.

4.3 Confounding factors

4.3.1 Small point sources of pollution

Discharges from private sewage treatment systems (PSTSs) may have a localised effect on water quality depending on the proximity and connectivity of the PSTS to the water body and its operating condition. PSTSs include septic tank systems, cess pits and package sewage treatment systems. Significant inputs from these sources could confound the WQ benefits derived from remedial measures focused on farm infrastructure and agricultural land. The potential of these systems to contribute to the nutrient loading of water-bodies is recognised (Smith 1977; May *et al.*, 1997) but relatively little detailed research has been undertaken (Micah 2003). As a result their significance as a source of nutrients to water bodies is poorly quantified.

A survey of PSTSs was conducted in the Tegid catchment on behalf of Gwynedd Council by Selyf Consultancy (2002) and was reported in detail by Micah (2003). The survey identified 187 premises served by PSTSs within the catchment of Llyn Tegid (excluding those in the Treweryn catchment). Ninety eight of these premises were identified as being of high priority

for inspection due to their proximity to the lake. Of the systems inspected, only one third were deemed to be in a satisfactory condition; the remainder were either considered to be polluting or having the potential to pollute. Poor maintenance was identified as the principal cause of unsatisfactory PSTS performance.

The data provided by the Selyf report have been digitised on a Geographic Information System and mapped against the surface water drainage pattern and catchment boundaries (Figure 4.3). This shows that there are 33 PSTSs in the Twrch and 35 in the Llafar catchment (Table 4.5). Of these, only 13 were inspected by Selyf and 5 of these were deemed to be of poor quality. The flow-path distance from each PSTS to the nearest watercourse has also been calculated using a digital terrain model. The average distance to the nearest watercourse from the PSTSs was 161 m in the Twrch catchment and 240 m in the Llafar. However there were 19 PSTSs at a distance of 50 m or less from a watercourse.

Table 4.5. Summary details of the PSTSs in the Twrch and Llafar catchments

Item	Twrch	Llafar
Number of PSTSs	33	35
Number of PSTSs inspected	8	5
Number in poor condition	2	3
Mean flowpath distance from watercourse	161	240
Minimum flowpath distance from watercourse	<50	<50
Max flow path distance from watercourse	624	762
Number of PSTSs at or less than 50 m flow path distance from a watercourse	11	8

Using a simple per-capita export coefficient model, Micah (2003) provided a conservative estimate of the contribution of PSTSs to the total phosphorus load of Llyn Tegid, as somewhere between 5 and 15% over the period 1996 – 1999 (excluding any contribution from the Treweryn). This estimate assumed that the PSTSs were working properly and that the average number of people served by a single PSTS was three. The actual contribution is likely to be higher given that the majority of systems were in poor condition and nearly half the systems were connected to rainwater drainage. A number of PSTSs probably served more than three people annually as premises included cavaran / campsites, holiday homes and a hotel.

There are some key research questions to address concerning how much PSTSs contribute to surface water eutrophication; and the extent to which characteristics including their condition, age, location and drainage field characteristics influence this contribution. However, given the high dependence of rural communities on PSTSs for sewage disposal, it would seem prudent to consider an assessment of PSTSs within CSF schemes. This might

provide rapid WQ benefits if PSTSs were identified as significant sources of pollution and remedial measures could be funded under the terms of CSF capital grants (although it is recognised that primary responsibility for ensuring that PSTSs are adequately maintained rests with the Local Authority).

4.3.2 Plantation forestry

The Llafar catchment in particular includes some areas of plantation forestry. Unless management operations are in progress, undisturbed forestry plantations are generally not a major source of nutrients or suspended sediments to surface waters although in acid sensitive areas they may contribute to acidification. Two phases of forest operations pose a risk of diffuse pollution to water courses. The initial stages of ground preparation and road building during forest development carry a significant risk of sediment pollution unless operations are managed carefully in accordance with industry guidelines (Nisbet 2001; Forestry Commission 2003). In upland areas, soil nutrient status is generally low so that the risk of nutrient inputs to water bodies associated with sediments lost from sites undergoing afforestation is small. During forest harvesting, soil disturbance by machinery and modifications to road infrastructure can lead to increased river sediment loading, although again unwanted effects of these operations should be minimised by adherence to industry guidelines (Nisbet 2001; Forestry Commission 2003). Release of nitrate and potassium into water courses is now a well recognised consequence of forest harvesting resulting from disturbance of the forest nutrient cycle and nutrient release from the soil and tree debris. The nitrate 'pulse' generally lasts for 2-5 years depending on the size and duration of the felling operation, whilst the release of potassium is short lived (1-2 years post harvest) (Neal and Reynolds 1998; Neal *et al.* 2004). Phosphorus may be released during harvesting operations on poorly drained gley soils, but the effect on the water course is usually very localised (Neal *et al.* 2003).

4.3.3 Sewage treatment works

The Llafar and Twrch catchments both contain small sewage works and effluent quality has been monitored by the Environment Agency. Mean Nutrient concentrations in the effluent are an order of magnitude greater than those measured in the streams at the catchment outlets implying significant dilution (Table 4.6).

At low flows the dilution factor will decrease and the STWs will become more important contributors to the concentrations of nutrients measured in the streams. Without flow data for

the streams and the effluent it is not possible to assess the contribution of the STWs to the total flux of nutrients reaching the lake.

Table 4.6. Arithmetic mean nutrient concentrations in STW effluent and at the outlets of the Twrch and Llafar catchments.

Site	Twrch STW	Twrch catchment	Llafar STW	Llafar catchment
NH_3-N mgN l^{-1}	3.53	0.035	8.15	0.03
NO_3 mg l^{-1}	9.54	0.5	8.7	0.462
Orthophosphate mg l^{-1}	0.595	0.011	2.787	0.011
Suspended sediments mg l^{-1}	25	2	41	2

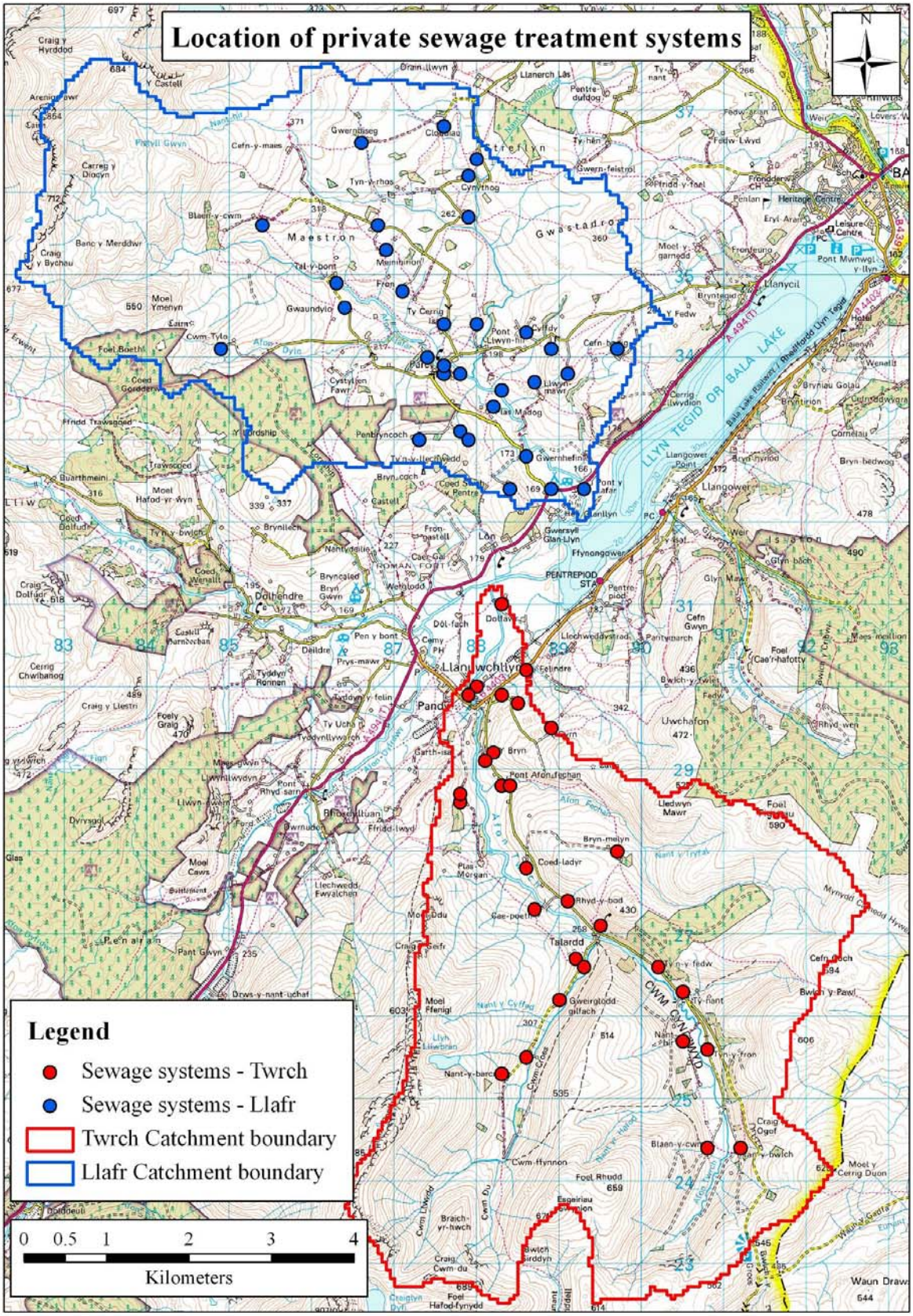


Figure 4.3. Location of Private Sewage Treatment Systems in the Llafar and Twrch catchments

4.3.2 Rainfall and runoff

The pattern of rainfall, particularly in relation to antecedent dry spells has been identified as an important factor exacerbating pollution incidents in the Deepford Brook catchments. In addition to washing material from surfaces, it is probable that ammonium is mineralised from organic-N sources during the re-wetting process and this adds to the effects of material washed directly in to the ditches and streams. At Llyn Tegid, soil erosion may be exacerbated by cracking during dry spells and by frost action during the winter in addition to any effects of poaching and farm traffic on wet soils.

It is important therefore to assess the effectiveness of farm scale remedial measures in the context of the prevailing patterns and amounts of rainfall and preferably in relation to long-term (30 year+) records. There are no permanent flow gauging structures within the CSF catchments, but representative long-term hydrological data can be provided from the Dee at New Inn for the northern catchments draining in to Llyn Tegid and the Eastern Cleddau at Canaston Bridge for Deepford Brook (Table 4.7). The flow and catchment rainfall data were provided by the National River Flow Archive (NRFA) hosted by CEH Wallingford.

Tegid catchments

The Dee at New Inn is located at the south western end of Llyn Tegid, drains a 54 km^2 upland area and contains the Afon Lliw as well as the Afon Dyfrdwy. The Afon Twrch is the adjacent catchment to the east and the Afon Llafar catchment is about 3 km to the north. The catchment upstream of New Inn is rural and contains no influences which are likely to affect the flow record. The NRFA notes that the gauging point is probably by-passed by extreme flood flows.

Deepford Brook

Canaston Bridge is located 2-300 m upstream of the tidal limit on the Eastern Cleddau, about 5 km downstream of the confluence between Deepford Brook and the Afon Syfynwy. The catchment is relatively large (183 km^2) and contains two reservoirs (Rosebush and Llys-y-fran) which will influence the runoff response at Canaston Bridge. Flows measured at Canaston Bridge are also influenced by public water supply abstraction and effluent returns.

Table 4.7. Summary details of the gauging points on the Dee at New Inn and the Eastern Cleddau at Canaston Bridge.

Attribute	Dee at New Inn	East Cleddau at Canaston Bridge
National grid reference	SH 874308	SN 072153
Area (km^2)	53.9	183.1
Gauging station altitude (m)	163.5	5
Highest point in catchment (m)	750	536
Mean flow ($m^3 s^{-1}$)	3.07	6.05
95% exceedance (Q95) ($m^3 s^{-1}$)	0.237	1.055
10% exceedance (Q10) ($m^3 s^{-1}$)	7.824	13.31
1961-90 average annual rainfall mm	2020	1437

4.3.2.2 Rainfall

Catchment monthly rainfall data from 1968 to 2006 were provided by the NRFA for the catchments upstream of the gauging points at New Inn and Canaston Bridge. The figures were derived by mathematical interpolation of the monthly totals from raingauges within (or close to) the catchments. Data for 2007 were not available at the time of writing (April 2008) as they had not been supplied to the NRFA by the Met Office.

At New Inn, 2004 and 2006 were relatively wet years compared to the long-term 1961-90 average, whilst 2005 was closer to an 'average' year (Figure 4.4). Years 2004 to 2006 were within 50 mm of the 1961-90 average catchment annual rainfall at Canaston Bridge (Figure 4.4). Comparison of the catchment monthly rainfall totals throughout 2004 to 2006 with long-term average values (1968-2003) emphasise two aspects of the British climate: i) the large month to month variations in rainfall totals within a given year and ii) the large inter-annual variations in rainfall for a given month (Figure 4.5).

4.3.2.3 Runoff

The hydrographs for New Inn and Canaston Bridge cover the period 2004-2006 in Figures 4.6 and 4.7. The hydrograph for the E Cleddau shows a much more damped response compared to the Dee at New Inn reflecting both the difference in sizes of the catchments (183 km^2 vs. 54 km^2) and the influence of the upstream impoundments which probably account for the shallower recession at Canaston Bridge. Whilst the E Cleddau at Canaston Bridge can provide an indication of hydrological conditions in Deepford Brook, it is too far down the catchment to use in the CSF assessment. The Dee at New Inn is probably more representative of conditions in the Twrch and Llafar catchments.

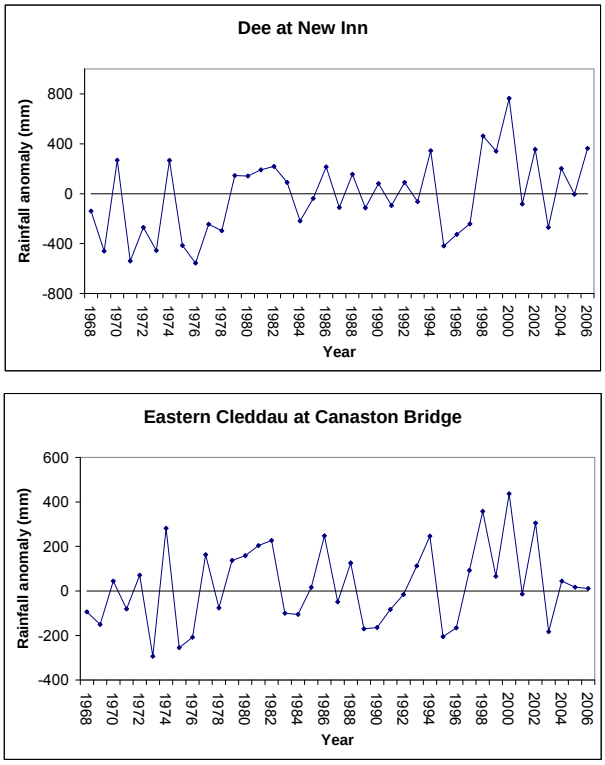


Figure 4.4 Changes in catchment annual rainfall from 1968-2006 relative to the 1961-90 average for the Dee at New Inn and the E Cleddau at Canaston Bridge.

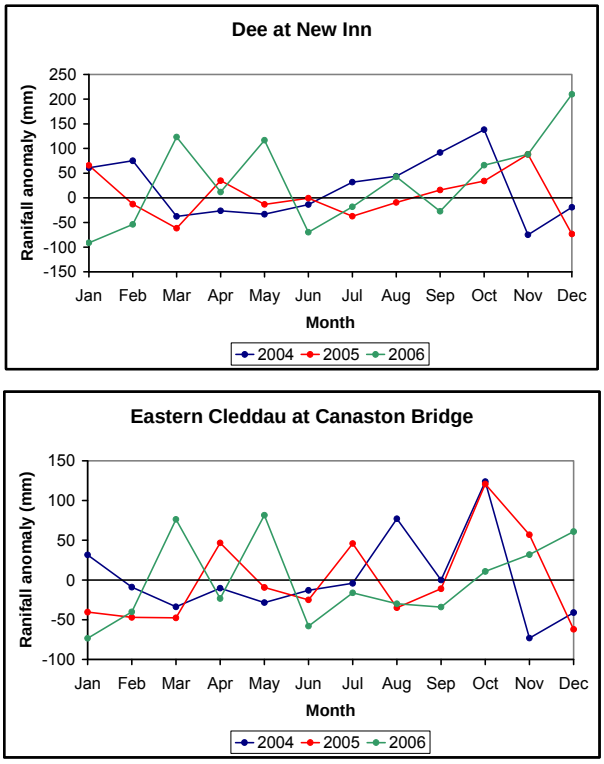


Figure 4.5. Catchment monthly rainfall totals for New Inn on Dee and the Eastern Cleddau at Canaston Bridge compared to 35 year monthly average values.

In both catchments there was a period of sustained high flows from October 2006 to February 2007. Most noticeable, and in contrast with 2006, the summer of 2007 had a period of relatively high flows sustained for July and August. This is consistent with observations elsewhere in the UK (Marsh and Hannford 2008) although the summer rainfall in north Wales was less extreme than experienced elsewhere in Britain (T. Marsh pers comm 2008).

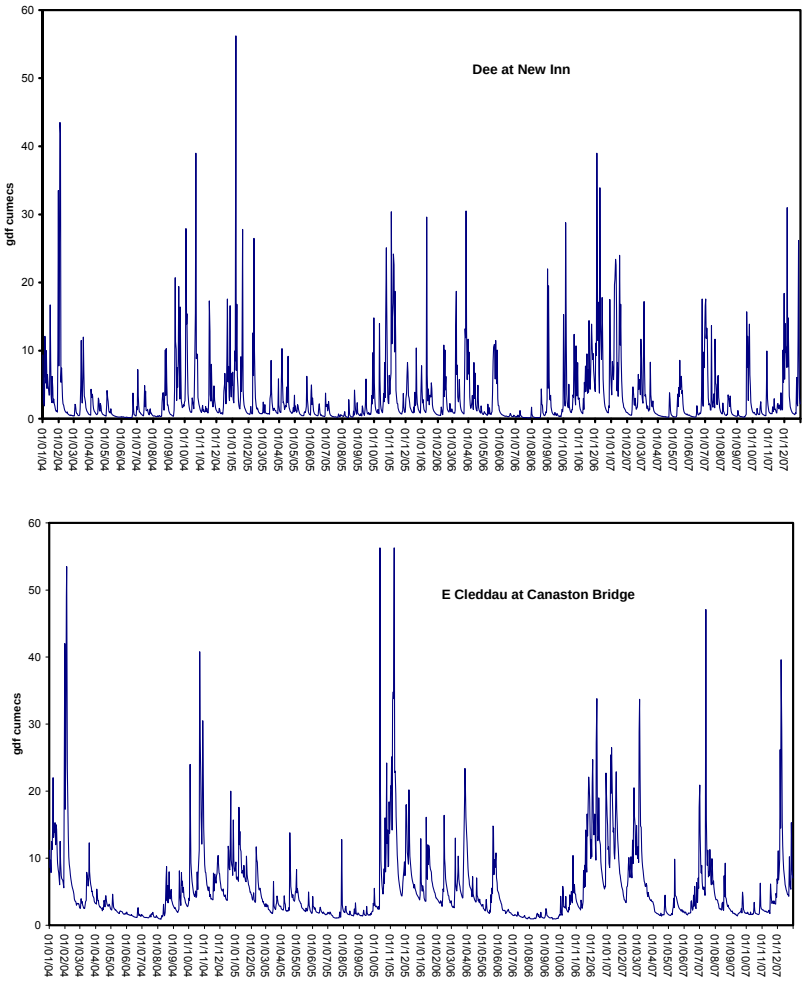


Figure 4.6. Gauged daily flows for the Dee at New Inn and the Eastern Cleddau at Canaston Bridge between 1st January 2004 and 31st December 2007.

4.4 Soil analyses

Soil nutrient data have been collected for farms participating in the CSF project. The sampling is very detailed providing field by field information for each farm. Olsen-P has been measured as the standard method for assessing 'soil available P' and hence agronomic requirements for P fertilisation. Olsen-P, however, does not provide a very reliable indicator of the likely consequences of soil P status for runoff and stream water quality resulting from leaching of soluble P forms in to water courses or desorption of soil bound particulate P in

the water column. This requires a measure of the capacity of the soil to sorb P as well as an indication of how much P is actually present in the soil in an 'available' form.

A large amount of research has been undertaken to provide a reliable indicator of soil P status for diffuse pollution assessment. One approach has combined measurement of Olsen-P with measurements of soil organic matter content and phosphorus sorption index to predict the value of the equilibrium P concentration in solution at which there is no exchange of P from the soil to solution or vice versa (Hughes *et al.*, 2000). An alternative soil test has been developed by the DESPRAL project (DEFRA 2004). Following a review of available methods, the test was developed under standardized laboratory conditions to predict the potential mobilisation of sediment, total P and dissolved P from a set of 26 EU benchmark soils. The orginators claim the method to be simple to operate and very reproducible. The DESPRAL soil test feeds directly into the diffuse pollution risk methodology incorporated in the PSYCHIC (Phosphorus and Sediment Yield CHaracterization In Catchments) decision support tool.

It would be advantageous to future CSF projects to incorporate an environmental soil-P test alongside the conventional agronomic Olsen-P test. This would provide more appropriate information for water quality risk assessment and modelling whilst at the same time supplying farmers and agricultural advisors with the information required to assess and, where needed, modify fertiliser use on the participating farms.

4.5 Comments on the design of WQ monitoring programmes for CSF evaluation

Only about 5% of the budget of operational EC schemes is available for monitoring and evaluation. Given the high costs of sampling and chemical analysis it is important therefore that the WQ monitoring programme is highly focused and designed to identify changes in response to CSF interventions. The pilot study experience has shown that catchments are highly individual so that it is not possible or desirable to be prescriptive in the design of a monitoring programme. A number of principles can, however, be identified:

Objective of the monitoring programme. Although this may seem obvious, the WQ objective has a major influence on monitoring scheme design and relates directly to the criteria for success of the implementation of CSF within a particular catchment. The pilot study provides a good example. In the context of the concerns about eutrophication in Llyn Tegid, a valid objective for CSF implementation in the Llafar and Twrch catchments would be to reduce the annual load to the lake of phosphorus associated with suspended

sediments. In contrast, a valid objective for CSF implementation in Deepford Brook might be to eliminate the incidences of unacceptable DO suppression in headwater streams. These two objectives would require very different monitoring schemes in order to identify whether CSF implementation had been successful.

Understanding the water quality problem. This provides another fundamental element of the design of the monitoring scheme which will help target limited resources most effectively. Considering the pilot catchments further; previous work at Llyn Tegid (Millband *et al.*, 2004) identified that channel bank erosion and wash off from improved pasture during high flow events were the major vectors for transport to the lake of phosphorus associated with suspended sediments. Assuming CSF measures were implemented to reduce this aspect of diffuse pollution, it is clear that WQ monitoring should be targeted towards capturing these events and less effort should be expended on sampling during low flow conditions. In Deepford Brook, previous work had indicated a problem with high ammonia concentrations and dissolved oxygen suppression. In this case strategically placed 'sondes' for continuous monitoring of ammonia, suspended sediments and dissolved oxygen might be more effective than manual spot sampling for detecting a response to CSF measures; especially as DO concentrations vary diurnally with a night time minimum. In both cases, low frequency, routine manual sampling is unlikely to provide good evidence of WQ change in response to CSF measures and may even provide misleading information.

Given clearly defined objectives and a satisfactory understanding of the problem, there are statistical techniques which can be applied to the design of WQ monitoring programmes in order to optimise sampling frequency for detecting pre-determined levels of change or assessment of total loading (Cooper and Watts 2002).

Understanding the catchment. Catchments are complex geographical entities which are subject to a variety of interacting influences which can confound simple cause-effect relationships between catchment management and WQ response. Several of the more significant influences have been reviewed in Section 3.3 and from this it can be seen that the catchment should be carefully appraised at the outset with respect to factors affecting water quality. These may influence both the choice of sampling locations and sampling frequency and affect the interpretation of the results. Furthermore, inherent features of the catchment such as hydrological response to rainfall ('flashiness') and the anticipated concentrations of target analytes must also be considered.

Accounting for 'natural' variability. The behaviour of many WQ parameters is intimately linked to hydrological conditions which, as the pilot study shows, can be highly variable over a range of timescales. Biological processes can also influence WQ at inter-annual, seasonal

or diurnal timescales. To be successful, the monitoring programme has to demonstrate the effectiveness of the CSF measures against this background of natural variability. For this to be achieved, some form of reference or control catchment is required against which to compare data from the catchment subject to CSF measures. In reality it is difficult to replicate catchments in a strict statistical sense so a paired catchment approach is commonly used. Ideally the two catchments should have similar physical, land use, hydrological and hydrochemical attributes prior to manipulation and be located reasonably close to one another. One option might be to compare sampling sites upstream and downstream of the CSF manipulations.

A further pre-requisite in the comparison of control and manipulated catchments is to ensure that there are adequate baseline (pre-intervention) data from both sites. Based upon an understanding of the catchment and the water quality issues, the baseline data should, as far as possible, encompass the range of factors likely to influence WQ behaviour. In the Tegid catchments, for example, this might mean sampling high flow events representative of seasonally varying soil moisture conditions as this affects soil hydrological pathways as well as erosion and transport of soil particles. Given appropriate baseline data, it is possible to use statistical techniques (eg Randomised Intervention Analysis; Uddameri *et al.* 1995) to detect non-random changes in paired catchment WQ data.

Practical considerations. Water quality sampling and chemical analysis is expensive. There are however, ways of reducing running costs by using automated equipment, measuring surrogate determinands and employing 'local' staff. In Deepford Brook, WQ monitoring 'sondes' were successfully deployed (albeit for a short time). At Pontbren, a sub-catchment of the upper Severn, similar equipment was maintained at relatively low cost for an entire year. These sondes recorded a number of high flow events with elevated turbidity and ammonia concentrations indicating sources of pollution upstream of the monitoring points. Routine sampling would probably have missed these events as they were relatively short-lived and occurred at any time throughout the 24 hour period.

The fine resolution 'event' sampling in the Tegid catchments gives detailed information about the concentrations of total-P and suspended sediments. These data can be used to define a relationship between the two parameters, such that monitoring of suspended sediments alone might give a cheaper, acceptable estimate of total-P or particulate-P concentrations. This could be extended further using continuous monitoring of turbidity which is itself a surrogate for suspended sediments. Adequate data are required to 'calibrate' these relationships, and the effects of compound errors due to reliance on modelled relationships between parameters must also to be considered.

Sampling under high flow conditions is usually difficult without specialised sampling equipment or staff who can be deployed at short notice. Even where such staff are available, unless they are locally based, they will probably miss the critical events. CEH have had considerable success in employing suitably trained local people to collect water quality samples. Providing they are adequately briefed, their flexibility and local knowledge of the water bodies can be used to great effect in capturing high flow events. Within the context of CSF, this could provide an additional element of local involvement with the project.

Chapter Summary:

It is clear that any CSF project must have well-defined water quality objectives so that monitoring resources can be deployed effectively. The water quality problem must be well understood in order to tailor a flexible monitoring programme towards the most effective sampling regimes. Statistical methods are available to guide this process.

However catchments are complex geographical entities which must be thoroughly appraised to identify confounding factors which might influence the choice of sampling locations and frequency, as well as affect the interpretation of the results

If budgets permit than due consideration should be given to selecting reference or un-manipulated control sites and to collecting appropriate pre-intervention baseline data. This maximises the power of the monitoring data, and increases the chances of being able to detect responses to CSF measures.

Practical options are available to minimise the running costs of CSF monitoring, which may also increase local participation in the project.

CHAPTER 5. ECONOMIC EVALUATION

Background and methods

The CSF pilot project provided financial support to farmers in order to reduce the pollution hazard from their holdings. The rules by which financial support may be provided to farmers are governed by relevant national and European legislation. Largely for these reasons, an assessment of farms was made by relevant authorised staff in order to consider potential activities which could both reduce the hazard from water pollution, and also be eligible for financial support. Eligible activities within the CSF project include infrastructure and capital works. This is unusual in the context of current agricultural support mechanisms that operate in the UK. Although financial support was provided to farmers in the 1980s in order for them to upgrade capital items on their farm that may have had a risk of polluting water courses, e.g. silage pits and slurry pits, these grants ceased to be offered in the early 1990s. Their cessation was in-line with political philosophy of the time (Edwards-Jones & Mitchell 1995).

However, EU regulation does permit financial aid to be offered to farmers for capital works, but in accordance with article 4[2] of EC Regulation 1857/2006 aid is limited to 60% of the cost of the capital works. Within CSF, aid for capital works is awarded solely on the basis that any funded work will provide environmental benefits through reducing the risk of diffuse water pollution. While in the first instance aid is limited to £10,000 per farm, exceptions of up to a further £10,000 may be awarded where the additional works deliver significant environmental benefit. The eligible expenses include:

(i) The construction, acquisition or improvement of immovable property
(ii) The purchase or lease-purchase of new machinery and equipment.

Within these two categories of expense, items will constitute eligible expenditure only where they mitigate pollution risks; which include:

(i) Fencing of watercourses
(ii) Provision of livestock watering facilities
(iii) Cattle tracks
(iv) Repositioning of gates
(v) Establishment of buffer strips
(vi) Yard works to separate clean and dirty water
(vii) Dirty water storage
(viii) New, modification or refurbishment of waste stores and silage effluent tanks
(ix) Waste and water pumps
(x) Sheep dipping infrastructure

A list of work categories for which aid is available, subject to further eligibility conditions, is shown in Table 5.1. Implementation is divided into relevant area of the farm 'yard' and 'field'. There are 11 types of yard works and 12 field works payable within the policy.

Exceptions to grant aid include:

(i) Investment will be limited to farms that fulfil minimum regulatory standards of environment, hygiene and animal welfare
(ii) Any cross-compliance breaches will need to be rectified
(iii) Aid is limited to *bona fide* farmers (through minimum experience conditions or by qualification)
(iv) The aid is not intended to bring farms in line with existing regulatory requirements
(v) The aid is not intended to fund the replacement of equipment unless additional environmental benefits are obtained
(vi) Aid is only available to farms producing goods for which normal market outlets exist
(vii) No aid will be provided for investments that increase production capacity.

Table 5.1: Works for which financial aid was available within the Catchment-sensitive Farming pilot project.

CSF Code	Yard Works
1Y	Separation of clean and dirty water
2Y	Roofing work
3Y	Dirty water storage
4Y	Galvanised heavy duty gates and galvanised posts
5Y	Waste stores
6Y	Silage effluent tanks and storage
7Y	Sheep dipping infrastructure
8Y	Water supply
9Y	Special projects
10Y	Concrete work
11Y	Hard surfacing
	Field Works
1F	General Fencing
2F	Fencing out watercourses
3F	Timber gates and timber posts
4F	Water supply
5F	Hard surfacing
6F	Stock tracks
7F	Culverts and bridges
8F	Wooden stiles
9F	Drinking bays
10F	Ford/crossing points
11F	Revetment - bank protection
12F	Special projects - as agreed with the Catchment Officer

Within CSF the ultimate adoption of different capital works varies with the farmers' preferences. As part of the scheme farmers were presented with a menu of pollution reducing measures by the project officers, and the potential choice of measures was discussed with these project officers. Farmers did not have a free choice as to what measures were adopted under the scheme. Rather if they wanted to adopt a certain measure, the project officer had to agree that this measure would reduce pollution on that

particular farm. While project officers tried to encourage the adoption of particular pollution-reducing measures on certain farms, ultimately if the farmers did not want to adopt any particular capital works, they were not forced to do so. This seems sensible given that the farmers themselves had to find at least 40% of the cost of any works. When viewed from an economic perspective this pragmatic approach to the scheme does raise some interesting research questions, such as:

(i) What influenced farmers' decisions as to which capital works to adopt?

(ii) Were the capital works adopted the ones that would have had the greatest impact on mitigating risk from water pollution?

(iii) What was the total cost of the capital works across the three catchments, and did it represent good value for money?

(iv) If this scheme were to be 'rolled out' across all of Wales, and the levels of adoption were similar to those in the pilot project, what would be the overall cost of the capital works?

(v) Did the capital works bring any additional benefits to the rural communities in the catchments and surrounding areas?

Some of these issues are addressed in this chapter. The chapter begins by documenting the actual costs of the capital works in the CSF pilot project. It then considers whether or not the capital works adopted had the potential to have a major impact on mitigating pollution. It finishes with a consideration of the more intangible elements such as benefits to rural communities and overall cost effectiveness.

Data on the costs of capital implementation on farms was provided by the project officers in the Llafar, Twrch and Deepford catchments. The economic analysis was completed several months before the end of the CSF pilot project, and for this reason the dataset used in the analysis may not include all costs for all farms which eventually adopted the scheme and undertook some capital works (n=47). This is inevitable given the timing of the evaluation and the project. However, even if some data are missing from the analysis, the data presented does provide a good insight into the capital investments made as part of the project.

What was the cost of implementing any infrastructure/ engineering type activities?

The cost of implementing engineering/infrastructure solutions for the different capital / infrastructure activities which occurred within CSF is shown in Table 5.2. The most expensive items were roofing works, with the development of waste stores, water supplies and dirty water storage being the next most costly group of items. Given the nature of these types of works this is not surprising. The cost of roofing works was fairly constant across catchments, but there was some variation in the other costs between catchments. This variation could reflect the nature of the works being done in the different catchments, but it could also be influenced by variation in local costs. However, this seems an unlikely explanation for difference between the Twrch and the Llafar which are geographically very close.

All except one of the 'yard' measures were adopted by at least one farmer. The only yard measure not adopted by any farmer was 'silage effluent tanks and storage' (code 6Y). This may be explained by the near-ubiquity of big bale silage. However, as noted later in this chapter improved storage of big bale silage, i.e. well located hard standing and roofing, is often required on farms. Further, given the environmental consequences of a leak of silage effluent from a store it may be prudent to maintain the silage effluent tank option in any future schemes just in case any farmers still utilise traditional silage pits.

How much did implementing these measures under CSF cost the taxpayer and the farmer?

Overall

The total value of works undertaken on the 47 farms included in this analysis was estimated at £922,348 (Table 5.3). This work was supported by £513,935 of grant aid. At 55.7% this is in accordance with article 4[2] of EC Regulation 1857/2006 limiting aid to 60% of the cost of the capital works. Average total costs per farm are estimated at £19,624; and for each of the 200 measures implemented the average cost is £4,612. Actual cost to farmers is the total cost less the approved grant; this is calculated as £408,413 or £8,689 per farm.

Table 5.2. Average unit cost of capital / infrastructure measures undertaken as part of the catchment-sensitive farming pilot project. Data were taken from the applications for support submitted by participating farmers. Note: not all activities occurred in all catchments. Costs are expressed in £.

Yard work	Average cost per measure implemented (All areas)	Twrch	Llafar	Deepford Brook
1Y Separation of clean and dirty water	£4,547		£2,760	£5,235
2Y Roofing work	£10,905	£10,601	£10,777	£11,554
3Y Dirty water storage	£4,709	£6,482	£4,774	£2,872
4Y Galvanised heavy duty gates and galvanised posts	£823	£612	£808	£914
5Y Waste stores	£7,952	£8,540	£8,231	£6,250
6Y Silage effluent tanks and storage				
7Y Sheep dipping infrastructure	£580		£580	
8Y Water supply	£5,500	£5,500		
9Y Special projects	£5,561			£5,561
10Y Concrete work	£5,246	£4,015	£7,106	£4,152
11Y Hard surfacing	£2,275	£1,300		£2,414
Field work				
1F General Fencing	£7		£7	
2F Fencing out watercourses	£1,417	£866	£760	£1,669
3F Timber gates and timber posts	£370	£480	£180	£451
4F Water supply	£338		£239	£358
5F Hard surfacing	£802	£740	£430	£949
6F Stock tracks	£8,324			£8,324
7F Culverts and bridges	£846		£846	
8F Wooden stiles				
9F Drinking bays	£406		£100	£508
10F Ford/crossing points				
11F Revetment - bank protection				
12F Special projects - as agreed with the Catchment Officer	£4,300			£4,300

Table 5.3: Cost of the actual suite of measures adopted in CSF N.B. This analysis was conducted before the end of the project; as a result these data may not exactly match the final expenditure figures).

Item	Approved Grant	Total cost of measures	Cost to farmer
Total	£513,935	£922,348	£408,413
Average per measure	£2,570	£4,612	£2,042
Average per farm	£10,935	£19,624	£8,689
Number of measures implemented	200		
Grant as proportion of full cost	55.70%		

Catchment - specific costs

Both Twrch and Llafar have implemented proportionally more yard measures than field measures. In Twrch this amounts to an average of £8,100 per farm (Table 5.4). Llafar has the highest average cost to the farmer at £10,426 per farm. The ratio of aid to total cost is similar in both of these northern catchments (Table 5.5).

Deepford Brook has the lowest cost to the farmer of the three regions at £7,562 and the largest proportional grant aid at 60% (Table 5.6). This may be due to the relatively large proportion of field works implemented in the region.

Table 5.4: Cost of implementing CSF in Twrch.(these data are based on a sample of 8 farms and may not match the final expenditure figures exactly).

Item	Approved Grant	Total cost of measures	Cost to farmer
Total	£70,278	£135,079	£64,801
Average per measure	£2,811	£5,403	£2,592
Average per farm	£8,785	£16,885	£8,100
Number of measures implemented	25		
Grant as proportion of full cost	52.03%		

Table 5.5 Cost of implementing CSF in Llafar. .(these data are based on a sample of 17 farms and may not match the final expenditure figures exactly).

Item	Approved Grant	Total cost of measures	Cost to farmer
Total	£194,093	£371,331	£177,238
Average per measure	£2,854	£5,461	£2,606
Average per farm	£11,417	£21,843	£10,426
Number of measures implemented	68		
Grant as proportion of full cost	52.27%		

Table 5.6 Cost of implementing CSF in Deepford Brook .(these data are based on data from 22 farms and may not match the final expenditure fugires exactly).

Item	Approved Grant	Total cost of measures	Cost to farmer
Total	£249,563	£415,938	£166,375
Average per measure	£2,332	£3,887	£1,555
Average per farm	£11,344	£18,906	£7,562
Number of measures implemented	107		
Grant as proportion of full cost	60.00%		

Did farmers adopt the measures that had the greatest impact in mitigating their risk of polluting water courses?

Background and methods to the pollution audit

Twenty-one farms which had joined the CSF scheme were visited by a team of staff to undertake a 'pollution audit' during the summer of 2007. The purpose of this visit was to identify all possible sources of pollution risk on the farm and to make recommendations as to the most practicable measure of reducing the risk. To some extent any audit of this nature is at least partly subjective, as different auditors may identify different hazards and suggest different solutions. In order to provide some level of consistency between the farm audits only two individual auditors were used, and both of these sought to provide solutions that were 'as close to zero as possible'. In other words they tried to recommend the most practical solution that genuinely reduced risk to almost zero (N.B. achieving zero risk is an impossibility). This method had the advantage of offering some consistency between

auditors, but it had the potential disadvantage that it tended to identify more hazards and suggest more expensive solutions than would a less rigorous approach. In addition it should be noted that in reality, achieving zero pollution is probably physically impossible and economically inefficient. In view of this, policy should aim to achieve acceptable levels of pollution risk at an acceptable social cost. So while in some ways asking the auditors to aim for 'close to zero' risk is highly artificial in a policy sense, it did provide a meaningful benchmark for analysis.

The audit team consisted to two members of FWAG who both held Fertiliser Adviser Certification & Training Scheme [FACTS] and BASIS Soil & Water Management Certificate qualifications.

The audit was conducted, at least in part, as a guided visit to each farm. Either the farmer or his appointed representative walked with the auditors around the yard area. Farmers were asked to describe their working practices, use of buildings, and their aims and intentions for the property. In turn, the auditors discussed the implications of the described building use and farming practices regarding risk of pollution. The audit then moved to the fields, paying particular attention to watercourses, and possible sources of diffuse pollution. At the time of the audit, the auditors did not know what measures had been applied for under CSF on any farm they visited. Both auditors did the majority of their work alone; however, in order to enable agreement of methodology and standards both auditors visited the first 5 farms together.

Working towards an 'as close to zero as possible' pollution remit the auditors and farmer considered:

(i) What changes to farming practices would reduce risk of pollution

(ii) What changes and improvements to the infrastructure of the farm would reduce pollution risk

(iii) Finally, on completion of the audit the farmer was asked how the proposed infrastructure changes would affect the farmers' working practices and expenditure

The approach adopted in the audit to meet the 'as close to zero as possible' remit is fundamentally different to the CSF (and many other) programmes and schemes. Most such schemes offer (usually in addition to obligatory measures) a range of prescribed alternatives from which the farmer can select his preferred options. These options will tend to be the ones which best fit the farmer's objectives, and will be limited by their means. Thus, while roofing a yard area may reduce overall pollution risk, the balance of direct costs and benefits perceived by the farmer may not make this a feasible option for them to adopt. However, if it is part funded for another reason, such as pollution control, it may then become a realistic

option. In other words the adoption decision is influenced by a combination of the objectives of the farmer and the objectives of the scheme. This is the basic objective of the CSF pilot project, however the pollution audit takes the opposite viewpoint and precludes any of the other aims or objectives a farmer may hold; it is concerned solely with minimising and controlling potential pollution.

Even though the auditors adopted an 'as close to zero as possible' remit, there was clearly some need for pragmatism in their approach. It would not be practical to consider complete redesign and redevelopment of the farm yard. Neither was it the intention of the audit to predict or recommend wholesale changes to operational practices or changes of enterprise in the search for pollution control. Rather the enterprises of the farm were assumed to be largely unchanged (i.e. a dairy farm will still be a dairy farm) and the best possible pollution control would be implemented using the existing infrastructure, and noting that only those measures which contribute to pollution control were to be considered.

A structure of lowest cost preferred measures were considered within an assessment of options which could reasonably be implemented given the rules regarding no change to enterprise and use of existing infrastructure. The following guidelines illustrate how this was implemented in practice in the assessment of a building. Its general principles were applied to other elements of the farm.

(i) Is the pollution control of the building suitable for its intended purpose?

(ii) Is the intended purpose a required use? i.e. could a change in management or practice make the building redundant?

(iii) If the building is needed and generally suitable to purpose

(iv) Can pollution control be improved by repairs/additions

(v) Consider lowest cost first, such as guttering and down pipes

(vi) If needed but not suitable,

- What measures/improvements are needed achieve the required standard?
- Can the building be brought up to the required standards at less cost than replacement?

(vii) When considering replacement, consider

- Is there another existing building that can be used / adapted?
- Can a yard area be roofed over to serve as an alternative?

Whilst a prescriptive list of measures was not used during the audits, there is indeed much that is common to many farms. For example, achieving better control of runoff by covering over dirty areas on the yard and fencing off water courses are practical solutions on many farms. Typically measures recommended for farm yards of farms in the audit included:

(i) Dirty water storage either tank or lagoon
(ii) Sheep dip store tanks
(iii) Slurry storage: tower or lagoon
(iv) New building, various purposes
(v) Roofing over of various yards, working and storage areas
(vi) Guttering and down pipes, either replacement, repair or new fit
(vii) Concreting of yard areas, either repairs to existing or new laid
(viii) Hard standing
(ix) Walling
(x) Fuel tanks complete with bunding

Measures recommended for fields of farms in the survey included:

(i) Fencing
(ii) Installation of culverts
(iii) Construction of drinking bays
(iv) Hardcore in gateways
(v) Piping of watercourses
(vi) Feed-pads
(vii) Track ways
(viii) Bridges over watercourses

An outline of the methodology used when conducting the audit is presented in Appendix 7.

Estimating costs

Estimated costs for the measures recommended by the pollution audit were obtained from SAC (2007) and from suppliers of materials and services to agriculture. Some adaptation was required from some of the SAC (2007) prices. For example the roofing over recommendation in the pollution survey equates to a simple building, framed and roofed but without walls and floor. Costs are calculated at the SAC (2007) quoted price for the simplest such structure of £55.00 per m^2 floor area. This contrasts with the new building costs of £190 per m^2 floor area which includes concrete flooring and walls. Actual costs used in the estimation are shown in Appendix 5.

N.B. In order to avoid any unintended consequences of participating in the audit the identity of the individual farms visited as part of the pollution audit is kept confidential in the reporting of the results.

Overview of pollution risks on farms

Changes to farming practices

A range of issues were discussed informally with farmers during the farm visits and the auditors noted responses. Most of those interviewed raised two points. First, that the only way to reduce pollution to zero would be to stop all activity on the land. Second, though

perhaps driven by other pressures, in terms of pollution their farming practices were already efficient.

For example, cattle are housed during the winter months simply because this followed conventional modern farming practices which are aimed at production efficiency. This reduces field based issues which contribute to pollution, such as poaching. Furthermore, it allows control of manures in terms of time of application and use of buffer zones and so on. However, it was noted that this produced a concentration of manures on the yard and certain infrastructure changes were required or had been made to address this.

Farmers felt that other potential pollution sources had been all but eradicated in the pursuit of efficiency and reduced costs: sheep dipping is no longer mandatory so few farms have fixed sheep dipping facilities, rather they used contracted portable facilities as required. While some farms retained silage clamps few use them other than to store big bale silage. Again the advantages in terms of handling, cost efficiency and so on appear to be the motivating factors, but reduced pollution is also obtained.

Having discussed these issues with the farmers the auditors agreed that generally fundamental changes to general farming practices did not offer practical options for reducing pollution risks. Thus, the only possible (though obviously undesirable) changes in farming practice relates to the first point most farmers made; to stop all activity on the land.

Changes and improvements to the infrastructure of the farm

The audits noted that within the farm yard the control of rain water dominated pollution control. Yards are, naturally enough, often located near watercourses and any run off has the potential of entering such water bodies. Manures, silage or other effluents stored on the yard all have the potential to contaminate rain water.

The infrastructure that is required to meet the needs of management and farming practices also contribute to the overall pollution risk. Few of the cattle handling areas, loafing yards and other non-housing areas on the yards have adequate control of rainwater. Further, yards are often located for convenience (such as access by transport) rather than consideration of pollution risk.

Given the current regulatory requirements, pollution control on yards tends to conform to a common standard. While some room to improve was recognized the cost of some changes, such as roofing over yards, was seen by farmers as prohibitively expensive.

That is not to say that any innovation in infrastructure is not apparent. Imaginative use of the topography allowed one farmer to tap a watercourse above the yard. The water drawn from

the stream was directed around housing in a series of water troughs before returning to the stream. The system provides clean drinking water to livestock, does not stand (and so become contaminated), incurs no running costs and was constructed from cheap, widely available standard plumbing hardware.

As a consequence of the present regulatory requirements, and where possible the implementation of imaginative solutions, many of the low-cost options to pollution control on farmyards have been to a great extent already implemented. Although there was some potential to achieve further reductions through repair and modernization, the larger proportion of any further reductions is likely to be through high cost- low impact options.

Away from the yards the main issues relate to preventing access by livestock to watercourses and erosion in gateways and other high traffic areas which may run cause run off. Preventing access to watercourses has two costs. First, the fencing to prevent access and second providing an alternative source of drinking water to the livestock. On some farms these costs can be considerable. While in the short term this may compliment the buffer zones in protecting water courses from diffuse pollution there are some questions over the longer term. For example, will some seasonal / low flow watercourses become overgrown and eventually blocked? Will they require cleaning and will this disturbance negate the earlier reductions in pollution? Further, any maintenance will be a further cost imposed on the farm. Likewise will the benefits due to the exclusion of livestock from watercourses be negated if watering points become high traffic areas and subject to poaching? Similarly, in other high-traffic areas, will hardcore or other measures simply relocate the problem to the interface between hardcore and field?

What measures did farmers in the pollution audit sample adopt?

Yard works

More than three-quarters (78.72%) of audited farms implemented at least one measure to mitigate or control pollution on farm yards. Roofing work was the most common measure (55.32%) followed by waste storage (36.17%), separation of clean and dirty water (31.91%) and concrete work (29.79%). Implementation of at least one measure to the farm yard was somewhat greater in the northern farms than in Pembrokeshire at 87.50% and 82.35% in Twrch and Llafar respectively compared to 72.73% in Deepford Brook (Table 5.7).

Each area was distinct in terms of the measures implemented and the rate of implementation. While roofing was the most common measure adopted in Twrch and Llafar the uptake rates were different; being 62.50% in the former and 82.35% in the latter. The

proportion of farms carrying out concrete work, the next most commonly implemented measure in Twrch was almost twice that in Llafar; the situation was reversed regarding waste stores.

Patterns of implementation in Deepford Brook were clearly different from those in the two northern catchments. The most common measure implemented in Deepford Brook was separation of clean and dirty water (45.45%), followed by special projects (36.36%) and then roofing work (31.82%). In contrast roofing work was the most common measure in the two northern areas, and special projects were not implemented. These differences may be explained by the different natures of the farming systems in the southern and northern catchments.

Silage effluent tanks and storage work were not implemented in any of the catchments. The near ubiquity of big bale silage and therefore alternative storage methods may account for this.

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Table 5.7: Take-up of Yard works by farmers in the audit sample (% of farms = implementing at least one instance of measure). NI – not implemented.

CSF work category	All areas	Twrch	Llafar	Deepford Brook
1Y Separation of clean & dirty water	31.91%	NI	29.41%	45.45%
2Y Roofing work	55.32%	62.50%	82.35%	31.82%
3Y Dirty water storage	6.38%	12.50%	5.88%	4.55%
4Y Galvanised heavy duty gates and galvanised posts	17.02%	12.50%	23.53%	13.64%
5Y Waste stores	36.17%	37.50%	64.71%	13.64%
6Y Silage effluent tanks & storage	NI	NI	NI	NI
7Y Sheep dipping infrastructure	2.13%	NI	5.88%	NI
8Y Water supply	2.13%	12.50%	NI	NI
9Y Special projects	17.02%	NI	NI	36.36%
10Y Concrete work	29.79%	50.00%	29.41%	22.73%
11Y Hard surfacing	12.77%	12.50%	NI	22.73%
% of farms implementing at least one measure	**78.72%**	**87.50%**	**82.35%**	**72.73%**

Field works

Patterns of implementation for field work were the opposite of yard works, with 95.54% of farms in Deepford Brook implementing some fieldwork measures compared with 62.50% and 53.94% for Twrch and Llafar respectively (Table 5.8).

While fencing of watercourses was the most common measure in all areas, the rates of implementation vary considerably, from 23.53% in Llafar to 68.18% in Deepford Brook.

Together with gates and hard surfacing there were only three measures which are implemented in all areas. Culverts and bridges were implemented only in Llafar and stock

Table 5.8. Take-up of Field works (% of farms at least one instance of measure)

CSF work category	All	Twrch	Llafar	Deepford Brook
1F General Fencing	2.13%		5.88%	
2F Fencing out watercourses	46.81%	37.50%	23.53%	68.18%
3F Timber gates and timber posts	27.66%	12.50%	23.53%	36.36%
4F Water supply	23.40%	NI	11.76%	40.91%
5F Hard surfacing	40.43%	25.00%	29.41%	54.55%
6F Stock tracks	12.77%	NI		27.27%
7F Culverts and bridges	8.51%	NI	23.53%	NI
8F Wooden stiles	NI	NI	NI	NI
9F Drinking bays	6.38%		5.88%	9.09%
10F Ford/crossing points	NI	NI	NI	NI
11F Revetment - bank protection	NI	NI	NI	NI
12F Special projects	2.13%	NI	NI	4.55%
% of farms implementing at least one measure	**74.47%**	**62.50%**	**52.94%**	**95.45%**

tracks in Deepford Brook only. There were no special projects implemented on the northern farms. The differences in uptake of these measures may in some way reflect both the farming system and their recent policy history. For example, many of the farms in the Llafar catchment had been members of agri-environment schemes for many years (e.g. Tir Cymen & Tir Gofal). As a result they had already fenced off many of their waterways.

Stock tracks were not implemented in the two northern catchments. The implementation of these options was discussed with farmers during the audit visit but none thought them necessary or likely to be effective. This view arises from the existing management methods in these catchments which farmers believe are unlikely to change in the foreseeable future. Generally in the northern catchments stock were not moved during periods of pollution vulnerability (i.e. when the ground is wet), and / or movement did not occur in places where farmers felt there was a risk of pollution to watercourses. Generally farmers felt that stock movement tended to occur existing hard surfaces and at periods when there is little risk of pollution. There was relatively low uptake of some measures that were offered in the CSF compared to the pollution audit recommendations. Few farms implemented drinking bays for example, and the greater proportion of those which did were in Deepford Brook. However, this is likely due to be related to fencing of watercourses; drinking bays are, obviously, only required where access to watercourses by livestock has been removed and this is greatest in Deepford Brook (68% of farms) and lowest in Llafar (25% of farms).

In addition to the silage effluent tanks already mentioned, a number of measures were not implemented on any farms in the pollution audit sample, these were:

(i) Wooden stiles
(ii) Fords/crossing points

(iii) Revetment-bank protection

It is interesting that none of these were recommended in the pollution audit.

Wooden Stiles were not considered to be a specific measure but may be needed given the considerable fencing recommended. In other words they are an additional cost imposed by the implementation of a recommended measure.

Given the problems associated with the development of ***fords/crossing points*** farmers tended to favour the use of bridges. All access to watercourses by livestock was strictly controlled in the pollution audit; fords or other crossing points contravene this restriction.

Revetment-bank protection was considered in the pollution audit, but was not found to be required on any farm.

Effect of suggestions from the pollution audit on the farm business

The recommendations from the pollution audit were discussed with farms at the end of the visit. Excepting initial capital costs of implementing any infrastructural change, farmers effectively foresaw business as usual. What, one could ask, are the difference in costs and working practices relating to a muck heap that is stored under cover compared to one which is in the open? There are no significant differences in operation, only that run off is controlled. Likewise if a handling yard or loafing yard is roofed over is of little consequence to those who work there.

This lack of apparent benefit to farmers may indicate a major difficulty at the root of any further implementations. As a consequence of the present regulatory requirements and drive for efficiency the remaining options for reducing pollution risk are the least business-favourable and more expensive measures. If these measures genuinely contributed to more profitable/efficient operation of the farm business then they would likely have already been implemented. If they were needed to comply with the present regulatory requirements then likewise, they would already be in place. As it is, they are the last remaining options, they are by default the expensive options and because they confer no benefits to the farm (i.e. they address an externality) there is little or no incentive to implement these measures only for the sake of addressing an externality. Where farmers perceive some direct benefit to the farm business from any new proposed measure, then the probability of uptake is likely increased. This issue is examined in subsequent sections comparing actual uptake in CSF and those measures proposed in the pollution audit.

What did the pollution audit suggest that was not included in the CSF measures adopted by the farms?

There was considerable difference between those measures that the individual farms adopted under CSF and what the pollution audit actually recommended could be adopted in order to minimise pollution risk (Table 5.9).

There are two identifiable groups of difference between the actual and recommended measures. The first is related to the rates of implementation for measures common to both schemes (i.e. how much of a given measure should have been undertaken) and second related to measures which were common (or not) to both schemes. As seen in Table 5.9, the pollution audit regularly recommended higher rates of implementation than were observed in the CSF, e.g. roofing works, fencing out watercourses and hard standing. However, the opposite was true for waste stores which were adopted at a higher rate under CSF than were recommended by the audit.

What are the farm costs of undertaking the measures recommended by the pollution audit?

A list of works recommended by the audit and the proportion of farms requiring them is shown in Table 5.10. The estimated costs of undertaking the full range of work on each farm recommended by the pollution audit are shown in Table 5.11. The costs per farm for undertaking the recommended measures range from a minimum of £12,544 to a maximum of £487,884.

The total cost for the 21 farms in the survey is £2.53million, an average of £120,653 per farm (Table 5.12). However there is considerable difference between farm costs in the north and south with the greater proportion of the total cost is attributed to the smaller Pembrokeshire sample. Average costs per farms are £76,920 in the north but are 2.7 times larger at £208,120 in the south.

Table 5.9. Implementation of measures as % of sample. Several measures are greater than 100%; this indicates more than one implementation per farm. e.g. roofing =267% indicates 2.67 roofs per farm.

CSF measures	Uptake in CSF	Pollution audit equivalent	Recommend in pollution audit
1Y. Separation of clean and dirty water	20	Guttering	52.38
2Y. Roofing work	104		267
3Y. Dirty water storage	8		66.7
4Y. Galvanised heavy duty gates & posts	44		
5Y. Waste stores	60		19.05
6Y. Silage effluent tanks and storage	0		
7Y. Sheep dipping infrastructure	4		9.52
8Y. Water supply	4		
9Y. Special projects	0		
10Y. Concrete work	36		76.19
11Y. Hard surfacing	4		33.33
Yard works in pollution audit only		new building	38.1
		retaining walls	9.52
		fuel tanks	71.43
1F. General Fencing	4		
2F. Fencing out watercourses	28		80.95
3F. Timber gates and timber posts	20		
4F. Water supply	8	piping	61.9
		lift pumps	57.14
		troughs	61.9
5F. Hard surfacing	32		42.86
6F. Stock tracks	0	3.2m hardcore	38.1
		drainage for track	9.52
7F. Culverts and bridges	16	culverts	52.38
		bridges vehicular	14.29
		bridges foot	4.76
8F. Wooden stiles	0		
9F. Drinking bays	4		42.86
10F. Ford/crossing points	0		
11F. Revetment - bank protection	0		
Field works in pollution audit only		feed pad	4.76
	manage watercourse	Divert	4.76
		Pipe	9.52
		watercourse drain	23.81

Table 5.10. The percentage of farms requiring recommended pollution mitigation measures – field works

Proposed measure	% of farms requiring measure		
	Wales	North	South
Fencing	80.95	100	42.86
Culverts	52.38	78.57	0
Drinking bays	42.86	64.29	0
Troughs	61.9	92.86	0
Pipework (25mm)	61.9	92.86	0
Lift pumps	57.14	85.71	0
Pipe watercourse	9.52	14.29	0
Hardcore gates	42.86	42.86	42.86
Feedpads	4.76	7.14	0
Trackways (3.2m wide)	38.1	35.71	42.86
Trackway drains	9.52	14.29	0
Divert drains	4.76	7.14	0
Bridge (vehicle)	14.29	21.43	0
Bridge (foot)	4.76	7.14	0

Table 5:11. The percentage of farms requiring recommended pollution mitigation measures – yard works

Proposed measure		% of farms requiring measure		
		Wales	North	South
Dirty water store	Tank	57.14	78.57	14.29
	Lagoon	9.52	0	28.57
Sheep dip store		9.52	14.29	0
Slurry store	Tower	14.29	0	42.86
	Lagoon	4.76	0	14.29
New building		38.1	57.14	0
Roof over	Farm yard manure	28.57	35.71	14.29
	Over lagoon	9.52	7.14	14.29
	Feeding area 1	33.33	0	100
	Feeding area 2	9.52	0	28.57
	Handling area 1	47.62	50	42.86
	Handling area 2	4.76	7.14	0
	Handling area 3	4.76	7.14	0
	Loafing area	14.29	0	42.86
	Silage store 1	28.57	0	85.71
	Silage store 2	19.05	0	57.14
	Silage store3	4.76	0	14.29
	Collecting yard	19.05	0	57.14
	Other	42.86	35.71	57.14
Gutter, replace		52.38	78.57	0
Gutter, new		52.38	42.86	71.43
Down pipe		76.19	85.71	57.14
Skim/repair concrete		19.05	21.43	14.29
New concrete	Clamp	9.52	0	28.57
	loafing	4.76	0	14.29
	feeding	4.76	0	14.29
	handling	33.33	35.71	28.57
	fym	4.76	7.14	0
New concrete total		52.38	42.86	71.43
Hard standing repair		23.81	35.71	0
Hard standing new		9.52	14.29	0
Retaining walls		9.52	14.29	0
Fuel tanks single		71.43	57.14	100
Fuel tanks double		19.05	28.57	0

Table 5.12: Estimated costs of implementing all works recommended by the pollution audit

Location	Estimated total value of works
North	£101,565
North	£46,227
North	£27,243
North	£50,763
North	£58,498
North	£12,544
North	£119,260
North	£20,584
North	£80,679
North	£123,379
North	£157,007
North	£65,079
North	£116,081
North	£97,963
South	£130,987
South	£229,479
South	£522,279
South	£112,868
South	£228,452
South	£97,725
South	£135,052

Table 5.13: Summary of costs of recommended measures in pollution audit

Item	All	North	South
Number of farms	21	14	7
Average cost per farm	£120,653	£76,920	£208,120
Total cost of farms in sample	£2,533,716	£1,076,873	£1,456,843

Table 5.14: Average cost of measures per farm

CSF measure	CSF	Pollution audit equivalent	Recommended in pollution audit
1Y. Separation of clean and dirty water	£809		
		Guttering	£284
2Y. Roofing work	£10,172		£10,911
3Y. Dirty water storage	£432		£1,214
4Y. Galvanised heavy duty gates and galvanised posts	£124		
5Y. Waste stores	£4,499		£2,748
6Y. Silage effluent tanks and storage	0		
7Y. Sheep dipping infrastructure	£22		£41
8Y. Water supply	£211		
9Y. Special projects	0		
10Y. Concrete work	£2,332		£5,345
11Y. Hard surfacing	£50.00		£432
		Yard works in pollution audit only	
		new building	£17,480
		Retaining walls	£164
		fuel tanks	£721
1F. General Fencing	£0.28		
2F. Fencing out watercourses	£225		£8,683
3F. Timber gates and timber posts	£48		
4F. Water supply	£19		£1,324
5F. Hard surfacing	£308		£64
6F. Stock tracks			£5,184
7F. Culverts and bridges	£144	Culverts	£271
		Bridges (vehicular)	£548
		bridges (foot)	£38
8F. Wooden stiles			
9F. Drinking bays	£4		
10F. Ford/crossing points			
11F. Revetment - bank protection			
		Field works in pollution audit only	
		feed pad	£30

What would be the cost if CSF were rolled out to all of Wales?

Background

The CSF pilot scheme was devised in order to trial a series of options that could be applied across Wales in order reduce pollution risk and help more toward compliance with forthcoming legislation, such as the Water Framework Directive. Obviously any national roll-out would require substantial financial resources. The purpose of this section is to take the data from the CSF farms and to use these to estimate the likely costs of implementing CSF across Wales.

There are several limitations in making any such calculations. The major one is that the farms in the three CSF pilot catchments may not be representative of all farms in Wales. This non-representativeness could relate to the proportion of farm types in the CSF catchments and in Wales, differences in size between farms and differences in the adoption rates. For these reasons these results need to be treated with some caution. They do however offer some very rough estimates of potential costs of any future roll-out.

Results

Estimated costs of implementing CSF were made on a proportional basis of the regional average costs for the north and south of the country made above and the number of farms in each region according to Welsh Assembly Government figures. In order to make some account for differences in costs of CSF on farms of different sizes several estimates were made using a 'cut-off' minimum farm size of 5 ha, 10 ha and 20 ha (Table 5.15). The total costs of running CSF across Wales can be estimated by multiplying the number of farms by the estimated average costs of CSF in each region (north and south Wales).

Table 5.15: Number of farms by size and location (data from WAG)

	all	>5Ha	>10Ha	>20Ha
North	21,671	14,121	11,969	9,725
South	15,297	10,362	8,531	6,470
All Wales	36,968	24,483	20,500	16,195

The cost of implementing CSF to all farms in Wales, regardless of size is estimated to be £685 million (Table 5.16). Based on the CSF pilot farms this would cost £404 million on grant aid and £281 million investment from farmers. However this is a highly unrealistic estimate as there are a large number of farms in Wales under 5ha which may not conform to the CSF regulations.

Table 5.16 Cost of implementing CSF in Wales (all farms)

	Grant	Total cost	Cost to farmer
North	£229,167,713	£438,976,176	£209,808,463
South	£173,525,796	£253,268,021	£79,742,225
All Wales	£404,236,868	£684,818,317	£280,581,449

A more likely scenario is to remove the smallest holdings from any national level CSF (Table 5.17). This results in a considerable reduction in costs to £454 million. Again given the CSF

average of 59% aid the bulk of cost is borne in grant aid (£268 million) and farmers paying the remaining £186 million.

Raising the cut-off point to 10 ha minimum size reduces costs further (Table 5.18) to £380 million, £224 million and £156 million for total, grant and farmers' costs respectively. Finally, the costs of the largest cut-off of 20 ha are shown in Table 5.19. Costs are reduced to £300 million, £177 million and £123 million for total, grant and farmers' costs respectively.

Table 5.17. Cost of implementing CSF in Wales (farms over 5 ha)

Area	Grant	Total cost	Cost to farmer
North	£149,327,547	£286,040,449	£136,712,902
South	£117,544,244	£171,560,648	£54,016,404
All Wales	£267,716,167	£453,538,381	£185,822,214

Table 5.18. Cost of implementing CSF in Wales (farms over 10 ha)

Area	Grant	Total cost	Cost to farmer
North	£126,570,456	£242,448,703	£115,878,247
South	£96,773,783	£141,245,309	£44,471,525
All Wales	£224,162,946	£379,754,802	£155,591,855

Table 5.19. Cost of implementing CSF in Wales (farms over 20 ha)

Area	Grant	Total cost	Cost to farmer
North	£102,840,478	£196,993,369	£94,152,891
South	£73,394,254	£107,121,925	£33,727,672
All Wales	£177,088,728	£300,006,293	£122,917,566

Impacts of targeting CSF

The figures presented above assume that any future scheme would be rolled out to all farms in Wales. In reality this may not be the case, and an alternative model would be to roll out new schemes into certain catchments, perhaps based upon their overall water quality and/or risk of pollution. However, it is difficult to estimate exactly the area of land that would need to be included in any such scheme. One problem is that different statistics suggest different levels of problem. For example, EA Wales suggest that according to the Water Framework Directive draft classifications 31% of river lengths failed the chemical quality standard, and 25% of rivers were felt to be in poor or bad ecological status (http://www.environment-agency.gov.uk/). Similarly EA Wales suggests that in 2007 10% of Welsh rivers had high concentrations of phosphate, compared 26% in 1990. A second problem, is that many of these statistics are related to the length of sampled rivers that are in a given classification, and it is not clear what area of land drain into these river lengths, nor is it apparent what

contribution agricultural pollution makes to pollution problem in these areas. For these reasons it is not possible within this study to present the costs of rolling out the scheme to a given set of catchments in Wales. Rather we present an estimate of the costs of doing this for a range of possible areas (Table 5.20). A key assumption of this analysis is that farms of different sizes are distributed evenly across the landscape, i.e. not all small farms are in one set of catchments and all large farms in another set. Given this assumption then the least expensive option would be to offer to CSF to all farms over 20 ha in catchments which cover 10% of the land areas. This would have an estimated cost of £30 million. Extending the scheme to all farms on 10% of the area would have a total cost of £69 million. The costs then increase as the percentage of land and farms in the scheme increases. These costs represent total cost of implementing the scheme. They do not make any assumption about the grant rate, and are therefore not necessarily equivalent to the Exchequer costs.

Table 5.20. Approximate costs (in £ million) of extending the catchment-sensitive farming scheme to other areas of Wales. The costs vary according to which farms are eligible to enter the scheme, and this is represented here by categories of farm size.

% of land in scheme	**Farms in the scheme**			
	(all farms)	> 5ha	>10Ha	>20Ha
10	69	45	38	30
20	137	91	76	60
30	206	136	114	90
40	274	182	152	120
50	343	227	190	150
60	411	272	228	180
70	480	318	266	210
80	548	363	304	240
90	617	409	342	270
100	685	454	380	300

What would be the likely benefits to local and regional economies of a CSF scheme?

Background

Schemes like CSF, which require developing infrastructure on farms, serve to increase demand for labour, services and physical resources in the immediate locality and beyond. The value of these 'knock-on' effects on the economy is estimated through the use of 'multipliers'. Put simply, a multiplier estimates the amount of additional expenditure that occurs as a result of a given investment. Thus giving farmers £100 to spend on fencing may stimulate activity in businesses which produce fence posts, move fence posts around the country, and grow or process timber.

Different multipliers can be applied to different sectors and localities. The multipliers used here were taken from two studies which have considered economic activity in Welsh rural areas: *Socio Economic Impacts of Adfywio* (Hyde *et al.,* 2005) and *Valuing our Environment – Economic Impact of the National Parks of Wales* (Hyde & Midmore, 2006).

The former employed original data in a Local Multiplier 3 (LM3) analysis (NEF, 2002). LM3 is a simplified design of multiplier analysis particularly suited to the estimation of local impacts. It employs the assumption of a local economy functioning within a wider (national or regional) economy. Having defined the area of interest (the local economy) spending is of two types: local spending and spending outside of the defined local area or 'leakage'. In a developed economy, most spending eventually leaks to the wider economy (to buy mass-produced goods, specialist services and so on). Within limits, this leakage is predictable; normally after three rounds of spending the impact of further spending is negligible. For example, a farmer purchases materials for fencing at a local wholesaler; this is the first round of spending and is contained within the local economy. The wholesaler uses a local source for the wooden posts, and a supplier outside the region for the wire fencing and other metal parts. This is the second round of spending, a proportion of which (the cost of the wire fencing and metal components) has leaked to the wider economy. Cost of the wooden posts is carried over to the third round; this includes a proportional component of the cost of labour at the wholesaler, and the spending of the supplier of the posts. In this round there are large leakages in terms of VAT, National Insurance, PAYE, machinery and transport costs, spending on consumer goods, mortgages and other financial transactions which in sum reduce a fourth round to insignificance. Thus the truncation of LM3 is supportable when considering a rural local economy. Hyde *et al* (2005) noted that multiplier coefficients estimated this way capture the propensity to deal locally resulting in slightly elevated coefficients when compared to national estimates. This was thought to be a function of the propensity to deal locally: this is determined by the willingness to deal locally (usually high in rural areas) and the availability of the required services. Normally, labour and close to primary products (the wooden posts in the example) are available locally, but capital goods are not. Therefore LM3 captures much of the total spending in the initial round but thereafter leakage is great. However it is an effective method of estimating local impacts and tracking investment. The coefficients in Hyde *et al* (2005) are used to estimate local impacts: these are for local spending and because of scale are not given for sectors.

Larger scale multipliers are estimated using input-output tables; those by Bryan *et al.* (2002) were used in the study by Hyde and Midmore (2006). The propensity to trade locally is not captured by this method, instead the national economy is used and consequently multiplier coefficients tend to be slightly lower.

The shapes of rural and non-rural economies tend to differ in terms of the sectors present, their scale and the nature of common sectors; it is therefore not likely that national coefficients are applicable to either. However there are technical problems in disaggregating national coefficients to constituent regions; Hyde and Midmore (2006) employed a gravity model to overcome this problem in respect of the economies of the National Parks of Wales. Coefficients estimated this way were not different to the surrounding rural areas but were different to the non-rural areas; they are, therefore, suitable candidates for use in estimating the impacts of an agricultural scheme such as CSF. These are given for the relevant sub sectors.

Local impacts

Local impacts are estimated by multiplying the total spending on implementing CSF (grant and farmers costs) with the coefficients estimated by Hyde *et al.* (2005). These estimates were made using the north-south figure for the number of holdings over 5 ha, over 10 ha and over 20 ha.

National impacts

Spending in CSF falls mainly to three sectors, Construction, Agriculture and Mining & Quarrying. All yard works, with the exception of galvanised gates and posts (5Y) and hard surfacing (11Y), and the field works water supply (4F) and culverts and bridges (7F) were allocated to construction. Gates (4Y) and fencing (1F and 2F) were allocated to the agricultural sector while any hard surfacing was categorised within the supplier of the materials, mining and quarrying. The estimated proportion of CSF spending in each sector is: Construction = 76.27%; Agriculture = 4.35%; Mining and quarrying = 18.94%. Hyde and Midmore (2006) estimated coefficients for those sectors as: Construction = 1.438; Agriculture = 1.421; Mining and quarrying = 1.297.

Impacts (as measured by the National multiplier coefficient) for all farms in Wales are shown below, for all holdings (Table 5.21); holdings over 5 ha (Table 5.22); holdings over 10 ha (Table 5.23), and holdings over 20 ha (Table 5.24).

Table 5.21. National economic impact: all holdings

Category	Cost	Coefficient	Impact
Total Cost	£684,818,317		
Construction	£525,364,083	1.438	£755,473,551
Agriculture	£29,770,719	1.421	£973,126,829
Mining & quarrying	£129,683,515	1.297	£681,397,216
		Total	**£2,409,997,596**

Table 5.22. National economic impact: holdings over 5 ha

Category	Cost	Coefficient	Impact
Total cost	£453,538,381		
Construction	£347,935,751	1.438	£500,331,610
Agriculture	£19,716,417	1.421	£28,017,029
Mining & quarrying	£85,886,213	1.297	£111,394,418
		Total	**£639,743,057**

Table 5.23. National economic impact: holdings over 10 ha

Category	Cost	Coefficient	Impact
Total Cost	£379,754,802		
Construction	£291,332,063	1.438	£418,935,506
Agriculture	£16,508,866	1.421	£23,459,098
Mining & quarrying	£71,913,873	1.297	£93,272,294
		Total	**£535,666,898**

Table 5.24. National economic impact: holdings over 20 ha

Category	Cost	Coefficient	Impact
Total Cost	£300,006,293		
Construction	£230,152,330	1.438	£330,959,050
Agriculture	£13,042,004	1.421	£18,532,687
Mining & quarrying	£56,811,960	1.297	£73,685,112
			£423,176,849

What would be the likely economic benefits to citizens of a CSF scheme?

Water quality is highly valued by UK society. Hanley *et al.* (2005) estimated the willingness to pay (WTP) for improvements to two rivers, the Clyde and the Wear, due to implementation of the Water Framework Directive. Their estimates varied between £12 and £67 (Table 5.25). Values are per-household WTP for an enhancement to the local sewerage operations. The valuation method employed by Hanley *et al*. (2005) estimates marginal benefits, that is the value in the change in welfare; this is described in the study as the change from 'fair' to 'good' quality in each of the three attributes.

Table 5.25. Willingness-to-pay for water quality improvements under WFD (after Hanley *et al*. 2005*)*

Attribute	Both Rivers		River Wear		River Clyde	
	Logit	RP Logit	Logit	RP Logit	Logit	RP Logit
River Ecology	£20.17	£18.19	£12.54	£12.19	£60.08	£38.70
Aesthetics	£16.91	£15.68	£12.35	£12.07	£42.38	£28.57
Bank sides	£21.53	£19.57	£12.92	£12.67	£67.08	£42.99

The total value for the change is calculated by the average household WTP multiplied by the number of relevant households. As both rivers pass through densely populated urban areas, then these values will be considerable. Clearly, this method focuses almost exclusively on use values (i.e. direct benefits) and other indirect benefits may also arise from an improvement in water quality.

Table 5.26 Willingness-to-pay for water quality improvements (after Georgiou *et al.*1996, Georgiou *et al.*2000, Bateman *et al.*2006, Bateman and Georgiou 2006)

Tame (Birmingham)	**Small improvement**	**Med improvement**	**Large improvement**
Fishing; Plants and wildlife; Boating and swimming	£8.64 (8.4 - 8.86)	£21.34 (20.75 - 21.88)	£31.50 (30.63 - 32.30)
Great Yarmouth and Lowestoft	**Bathing water maintained above EU quality standard**	**Improvement, or at least avoid deterioration**	
Seawater (bathing water) quality	£12.64(9.0-16.28) to £9.33 (-2.23-20.81)	£14.32(11.18-17.45) to £13.50(6.45-20.38)	
East Anglia	**Prevent eutrophication (P) in lakes and rivers**	**Avoid colour problems**	**Avoid smell & taste problems**
Drinking water / amenity water quality	£38.48 per household/year	£5.40 per household/event/year	£3.96 per household/event/year
Inner City Tame (Birmingham)	Small improvement	Med improvement	Large improvement
Fishing; Plants and wildlife; Boating and swimming	7.60 [6.14-9.05]	12.07 [9.83-14.33]	18.12 [15.13-21.48]

Other studies take a different approach to that of Hanley *et al*. (2005) and focus on recreation and abstraction (use-values) and amenity (passive-use) values (Table 5.26). As an example of use values DEFRA (1999) estimate the value of coarse fishing in Wales to be approximately £6.7 million.

DEFRA (1999) also provides estimates for the passive-use value of quality changes in terms of WTP / household / km of river / year at £0.002 and £0.005 for improvements of 'moderate to good' and 'poor to good' respectively. Again, these improvements are considerable given an estimated 1.5 million households and 3796 km of rivers in Wales. The WTP per year for an improvement of fair to good for half of Welsh rivers amounts to some £5.7million. It is worth noting that all the DEFRA estimates are at 1999 prices. It may not be valid to simply

adjust these to present prices as WTP will change with the changes in water quality in the intervening period (as evidenced by the difference in WTP for 'fair to good' and 'poor to good'). However, assuming a constant 3 % inflation over the intervening years then passive use value for the lesser improvement would amount to some £7.5 million.

Clearly, these values are illustrative of how considerable the values for improvements through the Water Framework Directive may be. For the purposes of future policy relating to CSF it is informative to note that given the estimated grant costs of implementing CSF at a national scale are £268 million, £224 million and £177 million for all farms over 5 ha, 10 ha and 20 ha respectively (Tables 5.17, 5.18 and 5.19), then assuming an adult population of Wales of 2.9 million, the benefits deriving from the CSF would need to be about £92, £77 and £61 respectively. These figures may reduce if we can assume that some people beyond Wales would also get some benefits from any enhanced level of water quality, such as tourism.

Chapter summary

The average cost of implementing measures within the catchment-sensitive demonstration project was £19,624. On average farmers contributed £8,689 towards these costs, and the grant constituted 55.7% of the full cost of the works.

Twenty-one farms which had joined the CSF scheme were visited by a team of staff to undertake a 'pollution audit' during the summer of 2007. The purpose of this visit was to identify all possible sources of pollution risk on the farm and to make recommendations as to the most practicable measure of reducing the risk of pollution to 'as close to zero as possible'. There was considerable difference between those measures that the individual farms adopted under CSF and what the pollution audit actually recommended could be adopted in order to minimise pollution risk. The pollution audit regularly recommended higher rates of implementation of measures such as roofing works, dirty water storage fencing out of watercourses and concrete works than were observed in the CSF. However, the opposite was true for waste stores which were adopted at a higher rate under CSF than were recommended by the audit.

The total cost of implementing the measures recommended by the auditors for the 21 farms in the survey is £2.53million, an average of £120,653 per farm. However there is considerable difference between farm costs in the north and south with the greater proportion of the total cost is attributed to the smaller Pembrokeshire sample. Average costs per farms are £76,920 in the north but are 2.7 times larger at £208,120 in the south.

If the CSF project were applied to all farms in Wales > 5 ha then the total cost would be £454 million. Raising the cut-off point to 10 ha minimum size reduces costs to £380 million, while only funding CSF on farms > 20 ha reduces the total costs to £300 million.

If such a large investment were made in rural Wales, then there would be knock-on effects within the rural economy, e.g. to suppliers of inputs. Using appropriate multiplier coefficients, the total impact of investing £454 million on farms under 5 ha would be in the order of £640 million, with the construction industry receiving the largest share of the extra activity. Smaller investments produce proportionately smaller impacts in the wider economy.

Decision-makers face difficult decisions when evaluating the costs and benefits of any such investment. No attempt was made within the project to measure the wider or social benefits that may occur due to the enhanced water quality resulting from the investments made in CSF. However, data from other studies which have made these estimates suggest that the public do perceive benefits in projects that enhance water quality. While there is a range of location specific benefit estimates, many of these suggest a willingness-to-pay of around £20 per person to be typical, with some studies suggesting a willingness to pay up to £67 / household. If the benefits of CSF accrue only to the population of Wales then in order to have benefits greater than the costs of implementation individual WTPs would need to be at least £61 for any scheme applied to farms >20 ha. If the scheme were applied to more farms than this, then the required break-even WTP would increase. If the benefits accrued to a wider population of Wales, say all tourists and visitors then again the break-even WTP would decrease appropriately.

CHAPTER 6. EVALUATION AND RECOMMENDATIONS

This chapter offers some comments on different aspects of the CSF pilot scheme, and makes some recommendations which may inform future schemes. These comments and recommendations have either arisen directly from the evaluation of the CSF pilot scheme, or they are direct responses to comments made by at least one farmer and/or stakeholder. The mention of any particular item here does not mean that it has necessarily been a weakness in the CSF pilot scheme; rather these comments and recommendations are made in order to highlight issues so that they may inform future schemes.

Start-up and initial stages

1. Comment: There is a potentially difficult balance when launching any new scheme, between communicating widely and managing the responses to that communication. Good attempts were made at the start of the pilot scheme to make contact with farmers, and there was a continued recruitment effort farmers over the first few months of the scheme. However despite these efforts some farmers claimed that they only heard of the scheme through informal channels and not as a result of any organised WAG campaign.

1. Recommendation: It is important to recognize that not all farmers respond to communication through letters. So it is necessary to use a diversity of communication methods including the local press, local organizations, and key informants in the community. Also it is important to maintain a 'campaign' of information over a few weeks in the early stage of a project in order to ensure that individuals who are away from home, or busy, get a chance to receive relevant information. However, in order to capitalise on initial interest to the information campaign, it is important that sufficient resources are available to deal with responses. Ideally a temporary 'response' group could be put together which would work for a short period only in order to deal with specific enquiries, and would then be disbanded and the core project officers could then be left to deal with subsequent enquiries (see Recommendation 6).

2. Comment: Holding a local meeting early in the project was a good idea. Farmers appreciated the personal contact made by the project staff. Similarly, holding a local meeting at the end of the project was also a good idea. It provided vital feedback to the farmers on the overall success of the project.

2. Recommendation: Ensure that local connections are made, hold local meetings and seek to develop a good personal relationship between project staff and farmers.

3. Comment: In the early stages of the project some of the farmers were a little confused about the aims of the project and what they would be required to do if they joined. Many of these early perceptions were slightly incorrect.

3. Recommendation: Ensure consistent and accurate information is given to farmers from the very beginning of the project. This is particularly relevant in voluntary schemes, as some early misperceptions may delay or prevent later adoption.

4. Comment: Some farmers doubted that there was any pollution problem in their area. This undermined their attitudes towards the scheme and may have affected their adoption decision. Similarly, at the end of the project many farmers were interested to know if the project activities had reduced pollution.

4. Recommendation: While it is difficult to demonstrate any impact of a two year project during the project's lifetime, it is possible to present long-term data on the pollution levels in any given area. Using these data to 'make the case' for action is an important element in motivating farmers to join the scheme. It is known from other studies that people only tend to adopt certain behaviours if they believe that there is a worthwhile issue which they can influence.

5. Comment: The farmers were not all motivated to join the pilot scheme by the same factors, and neither did they all recognise the same set of benefits from the project. Some felt the greatest benefit related to enhanced water quality, some to the grant aid for farm improvements, some to the reduced their risk of breaking any laws and some to the eased farm management.

5. Recommendation: When describing the project to farmers, ensure that a full list of different advantages is presented. Do not solely focus on the official aim of the project, but rather try and outline a range of potential benefits. Through presenting the full range of

benefits it is more likely that any given farmer will identify with at least one reason for adopting the scheme.

6. Comment: Some of the farmers commented that the process and flow of money was very slow at the start of the project. Given that these projects are very local and that farmers will inevitably discuss the project between themselves, it is important that early entrants have an excellent experience of the scheme. This will prevent any negative comments spreading amongst the farming community; which may delay / prevent adoption by some individuals. While there are many benefits associated with processing early entrants quickly, there are also practical problems associated with achieving this. Chief among these is that if the communication plan and recruitment are good, there will be significant interest in the scheme. It will then be difficult to process all of the early entrants very quickly using a small team of project staff. There are several potential ways around this. First is the option of recruiting extra staff to help process early entrants (a 'response' group). The advantage of this approach is that it hastens administrative process; but if these staff were to interact directly with farmers then it might serve to confuse or undermine the relationship between farmers and the dedicated catchment officers. So should this strategy be adopted, it would be best if the extra staff dealt with administrative issues; and did not have direct contact with farmers. Another option is to try to offer a managed approach by dealing with early entrants in some form of rota. For example this could use farm location, or even farmers' surnames. The logic here is that farmers may respond well to a strategy that said 'Thank you for your interest in the scheme, we are currently dealing with farmers according to the following rules, and we hope to get to you by date X'. After meeting with you on that date we will hope to complete your application within X days'. This sort of approach may elicit a better response from farmers than one where all early entrants were registered very quickly and then their application was managed in a less structured way. Inevitably there will be some criticism, whichever technique is applied. There may be some benefit in trialling different approaches in order to see which farmers prefer.

6. Recommendation: Try to process the applications of the first few individuals extremely quickly as this will offer substantial benefits in terms of good public image. If it is not possible to achieve this due to administrative constraints, then devise a system that actively manages the expectations of farmers, and communicates the timescale for dealing with their application.

7. Comment: Some farmers wondered why their area had been selected for the pilot project. There were various rumours circulating about the reasons for the selection of the different catchments. Some farmers felt that by being in the project area they had an advantage not available to others, and that somehow this was unfair. In the northern catchments some farmers noted that if the project aimed to reduce the pollution in Llyn Tegid, then there was a need to include other catchments, and also other sectors, e.g. forestry and tourism.

7. Recommendation: It may be best to clearly state the reasons that a particular area was selected for inclusion in the scheme, and to publish these in relevant communication materials.

8. Comment: Many farmers expressed interest in the CSF pilot scheme as a result of attending the initial local meeting. Once these farmers had been registered onto the scheme the project officers made personal contact with other farmers in target catchments and asked if they were interested in joining the project. This proactive approach to recruiting farmers is one of the reasons that overall adoption rates were so high in the CSF pilot project.

8. Recommendation: Ensure that project officers are enabled to make contact with farmers in order to try and recruit them onto the scheme. In addition project officers should seek to maintain personal contact with as many farmers as possible, both before and during the scheme. Informal social contact can be a very effective way of building trust and dealing with any small problems.

Communication with farmers and other stakeholders

9. Comment: Farmers in the Tegid catchment commented on the benefits of having communications in the Welsh language. Although the relevant organisations are generally aware of the desirability of offering Welsh-language provision to farmers, there are occasions when it is not possible to offer the highest quality technical input through the medium of Welsh (i.e. if there is only one 'expert' in the UK and s/he does not speak Welsh). When this occurs there is a need to take a balanced decision as to the importance of the language of delivery and the technical excellence of the input.

9. Recommendation: Maintain a high level of sensitivity to cultural and linguistic differences across Wales, and wherever possible, strive to offer communication in the most appropriate language. Where this is not possible, ensure that adequate translation facilities are

available. If it is necessary to have non-Welsh speaking staff interact directly with farmers, then explain that the issues of language had been considered, but on balance it was felt better to get input first-hand from the technical expert, rather than 'second-hand' from a Welsh speaker.

10. Comment: It is important to maintain contact between the project staff and farmers throughout the project's lifetime. It may also be important to communicate progress to other people outside the project. This sort of communication could inform these individuals about the pollution status of their rivers, describe the actions that farmers and other industries are taking to enhance water quality, and offer advice and encouragement to other residents for responsible action. Given the wide range of interests across any catchment, newsletters for such purposes may have to be different from those distributed to farmers.

10. Recommendation: The use of a regular newsletter which is distributed to all farmers within a catchment can offer valuable communication with farmers. A project website might also be developed, but it is unlikely that many farmers will access this on a regular basis (if at all). Traditional hard-copy newsletters, such as those dispatched to farmers during this project, remain a most useful means of communication. There may also be benefits to communicating with non-farming inhabitants of a catchment about the aims of catchment management. However, any newsletter aimed at a general audience should take a different focus from that offered to farmers.

11. Comment: The CSF pilot scheme was both innovative and potentially very informative to farmers and decision-makers. Although communication between officers and farmers within the target catchments was very good, there may have been greater potential to use the CSF pilot catchments to inform others about the work. For example, farmer groups from outside the catchments could have usefully benefited from visits to key farms in the catchments. This would have enabled them to see the work first-hand and also to discuss the workings of the CSF scheme with farmers and project officers.

12. Recommendation: Try to use the experience of pilot projects to inform farmers and stakeholders from outside the catchment. This might include farm visits and discussions with farmers and other stakeholders. Extension experience from around the world suggests that farmer-to-farmer knowledge exchange is extremely effective. Such visits could be particularly useful if farmers from areas that are designated to enter similar schemes could visit the CSF farms before, or early in, their particular scheme. It may also be useful for staff from associated organisations like Countryside Council for Wales and the Environment

Agency to visit the pilot catchments. This would enable them to see at first-hand the benefits of engaging directly with farmers in a positive manner.

13. Comment: Some stakeholders questioned the value of establishing the CSF demonstration project in Wales, given that similar projects were on-going in England. In some situations it may be possible to establish a set of pilot projects in one region of the UK and to use these to inform stakeholders across the UK. However, in other cases this may not be appropriate. On balance it seems that establishing demonstration projects in Wales was worthwhile, even if similar projects are established elsewhere in the UK. This is because the combination of farming systems, topography and weather makes the agricultural environment in Wales very different to that in much of England (and elsewhere in the UK). This is particularly important when dealing with issues of water pollution. Many of the catchment-sensitive farming initiatives in England are based in largely arable areas and have a focus on pesticide issues. Clearly this is not relevant to much of Wales. Given the importance of persuading farmers of the benefits associated with CSF, it is essential that they feel its relevance to them and to their farms. Cultural differences between England and Wales mean that many farmers need to see that certain practices work in the Welsh environment before they will engage with them. Finally, WAG are responsible for administering agri-environment schemes in Wales; it is important that relevant staff in WAG gain first-hand experience of initiatives like CSF.

13. Recommendation: Maintain pilot catchments and demonstration farms in Wales, even if similar works are on-going in England; as they are important factors in developing knowledge and experience among stakeholders.

14. Comment: Some stakeholders suggested that it may be useful to develop one 'demonstration farm' in a catchment that could be used to show best practice to farmers. Such ideas have a long history in extension, and the idea of a 'model farm' was standard practice in many countries in the post-war years. It has the advantage that all of the technologies can be developed in one place; a single location can then be used for a series of demonstration or extension events. The chief advantages of this approach relate to the efficiencies associated with both investing heavily in one location, and also of developing suitable demonstration facilities. There are also a series of disadvantages associated with this approach. For example, it is unlikely that one farm can really demonstrate best practice across all relevant issues. Even if it did have the potential to demonstrate a range of good practice, significant investment would be needed to achieve this. This raises two issues.

First, how would this investment be funded - and how much would the farmer be expected to provide? Second, major investment of public money into one farm could cause resentment in the farming community; undermining the value of the demonstration farm. Experience also suggests that demonstration farms have to work hard to maintain their technological 'lead', and that any failure of the facilities or system can have a severe negative impact on farmer morale and interest. Many of these disadvantages can be circumvented by having a series of farms in a catchment, each of which demonstrates best practice in at least one activity.

14. Recommendation: Develop a series of farms in a catchment, each of which can be used to demonstrate best practice in at least one activity. Used together, such a series of farms can demonstrate best practice across a wide range of systems and situations.

Operation of the scheme

15. Comment: Some stakeholders questioned whether the grant rate of 60% was too high. The issue of grant rate is a difficult practical and philosophical issue. The practical issue relates to the overall budget constraint present in all projects. If the grant rate is too generous, such as 100%, then fewer farms will be able to benefit from the scheme. However, if the grant rate is too small, such as 10%, then the adoption rates may be low. The philosophical issues relate to the purpose of the grant. The purpose of the CSF grant is to provide environmental benefits through reducing the risk of water pollution. Grants cannot be given as direct financial aid, or as a means to enhance production capacity.

From a philosophical viewpoint, the purpose of the grant is to encourage farmers to undertake work that is of no direct financial benefit to the farmer; but does provide social benefit through enhanced water quality. Why would a farmer invest any money in capital works that do not enhance production capacity? If there were truly no benefit to farmers then perhaps a grant rate of 100% would be acceptable. However, evidence from the farmer interviews suggests that while the capital works may not have had a direct impact on productive activities, they did serve to make the farmers' lives easier. For example, roofs meant that they no longer got wet when working in that area of the farm, while water management systems also tended to make yard management easier. However, these benefits are subjective, so different farmers will value them differently. Some farmers may not mind getting wet, while others may be very keen to develop roofing that stops them getting wet. For many, the decision as to whether or not to adopt a particular measure will comprise a combination of financial and psychological factors. The exact balance between

price and benefit will vary between farmers according to their personality and personal situation. Experimental surveys could offer some insights into the minimum level of grant that would attract a suitable level of adoption; however, no such surveys are available for CSF-type works in Wales.

In the absence of experimental information it is informative to examine the adoption rates of the demonstration project. Very high adoption rates may indicate that the grant rate was higher than necessary, while very low adoption may suggest it was too low. The actual adoption rates in CSF were quite high, but not 100%. In addition, several farmers commented that the grant rate was too low. One interpretation of these data is that the grant rate was too high, and that the negative comments reflect a minority view. Based on this interpretation it would be justifiable to reduce the grant rate. However, the risk of reducing grant rates in future schemes is that adoption could drop. This would then mean that the costs of establishing a project would not be balanced by the accrual of significant environmental and social benefits. Another interpretation of the situation in the pilot study is that the grant rate of 60% presented farmers with a good balance between incentive to participate and commitment to invest.

15. Recommendation: Given that the measures associated with CSF reduce pollution risk to a greater degree than is expected by both legal standards and cross-compliance, and do not offer direct financial return to farmers a grant rate of >50% seems to be the minimum to encourage adoption. Given that adoption in the CSF was good with a grant rate of 60%, there is no evidence that suggest a higher grant rate is needed. There is no empirical evidence which suggests exactly what level (in the range 50-60%) is optimal. Given the success of CSF, if there is a real need to reduce pollution risk in a particular area, a grant rate of 60% can be justified; and if the works really had no impact on the overall well-being of the farmer then perhaps grants of 100% would be philosophically acceptable.

16. Comment: Some stakeholders commented that the process of selecting measures to be adopted gave farmers too much freedom of choice. It is impossible to know if this is true, as the negotiation about which measures to adopt took place between the farmer and the project officer. Project officers had received instruction to try and get the farmers to adopt measures that had a significant impact on the risk of pollution. If farmers were not willing to adopt measures that brought significant reduction in the risk of pollution then project officers were instructed to abandon negotiations and consider removing the farmer from the CSF pilot scheme. No farmers were asked to leave the CSF scheme. However the evidence from the pollution audit does suggest that there may have been scope to adopt an

alternative set of measures to that chosen by the farmers, which would have brought about a further reduction in pollution risk. However, as the choice of measures was subject to negotiations between the farmer and the catchment officer, it was also affected by the amount of capital the farmer was willing to invest and by the cap on expenditure on any one farm. For this reason it is impossible to estimate if the final set of measures adopted on any farm was optimal or appropriate.

An alternative to negotiation around a fixed list of possible measures would be to classify potential measures in accordance with their generic potential to reduce pollution. Here, 'class 1' measures would include the works that typically have a large potential to reduce pollution risk; 'class 2' would include measures that typically have a medium potential for risk reduction, while measures in 'class 3' would typically have a small potential for risk reduction. The scheme could then be set up such that all farms had to adopt at least one 'class 1' measure in order to be eligible to enter the scheme. While such structured frameworks seem to reduce the scope for strategic behaviour by farmers, they also serve to remove considerable flexibility from the process. Consider for example, the situation of a farm which had no need to implement any 'class 1' measures because they had already made significant capital investment for other reasons, but they could benefit from a range of 'class 2' and '3' measures. Here the rigidity of the framework would prevent this farm adopting measures which reduced pollution risk. A second problem with these sorts of frameworks is that they do not take sufficient account of local environmental situations; so the 'risk classification' framework may not be equally applicable in all locations.

16. Recommendation: A list of measures that are eligible for funding should be developed and made publicly available. Project officers should receive training that would enable them to visit a farm and rank measures in order of the impact that they would have on pollution risk. They should then discuss each measure with the farmer in descending order and try to ensure that the most important measures are adopted. Project officers must be enabled to break off negotiations should farmers not be willing to adopt appropriate measures. If no appropriate training is available on ranking pollution measures by risk, then bespoke training courses need to be developed. Project officers may also benefit from training in negotiation skills. Project officers should write a brief report for each farm stating why particular measures where adopted and others were not.

17. Comment: Farmers claimed that staff from multiple organizations were coming to the farm, and that they sometimes gave conflicting or different advice. For most organisations the issue of 'branding' is important, but they are largely irrelevant to users.

17. Recommendation: It may be best simply to brand all staff as 'project staff'. Also, best practice would be for the project staff to be the sole conduit of information to the farmer; and to accompany all other project related visitors on any farm visit in order ensure consistency of advice.

18. Comment: Some of the farmers felt that a disproportionate amount of money was being spent on administration; and consequently too little on farm-based activities.

18. Recommendation: In order to allay fears like this it may be possible to publish figures about the percentage of the total project budget that will be spent on administration, evaluation and operations. This information would then allay any fears the farming community may have. It may be useful to consider publishing some form of annual accounts or expenditure profile via a website, or by some other means. This could be put alongside other project-specific information on progress to date and the latest water quality data.

19. Comment: Some of the farmers commented that, having decided to adopt certain capital works, there were then some problems in passing these through the local planning process.

19. Recommendation: The capital works options of any scheme could be discussed with relevant planning authorities prior to the beginning of the scheme. It may be possible to develop indicative guidelines to assist project staff and farmers in developing plans for future works. It may also be useful to involve local planning officers in meetings and open days with farmers.

20. Comment: Some farmers noted that it was difficult to get three quotes from contractors prior to undertaking their capital works. It was also suspected that, as the scheme progressed and contractors understood what was happening, their prices started to increase. These sorts of problems are to be expected in a rural area where limited contractors experience a sudden increase in demand for their services. Two issues are worthy of consideration. First, are there sufficient contractors available to do the work within the timeframe available for the project? Secondly, does an increase in the prices quoted by contractors pose any hazard to the successful outcome of the overall scheme?

20. Recommendation: Consider issues related to the availability of contractors in an area, and the related issue of cost. Is it possible to use standard prices, to apply ceilings to work

costs, or to enter into some other relationship with contractors to enable efficient delivery of the project? There are no easy answers here, but it is an issue worth considering.

Water quality monitoring and assessment

21. Comment: Water quality monitoring is potentially useful for four purposes. First, to confirm regulatory compliance with quality standards. Second, to demonstrate to farmers that there is a real problem with water quality in their area, that needs to be tackled. Thirdly, to demonstrate to farmers (and others) that the actions that they have adopted as part of any catchment-sensitive scheme have brought real benefits. Finally, these data can be used in a scientific way, to enhance understanding of the links between farm-level activities and water quality. Prior to undertaking any CSF scheme it is important to consider which of these purposes are most relevant, and to design a monitoring scheme accordingly. Normally, we can assume that regulatory monitoring is undertaken and funded as a normal part of the Environment Agency's activity, and that these data could also be used to demonstrate any problems to farmers. Similarly, research-related monitoring should be funded from a specific research fund. So the only monitoring that needs to be funded as part of a CSF scheme would be for demonstrating the efficacy of that particular scheme. Focusing in this manner offers some potential to identify the specific aspect(s) of water quality that need to be monitored; and to develop a suitable, robust strategy for achieving this. Narrowing the range of variables being monitored might lead to financial benefits. Similarly, a well designed monitoring scheme in a specific locality may be able to offer useful insights at lower cost than a wide-scale study.

22. Recommendation: Carefully define the purpose of any monitoring to be undertaken as part of CSF; and seek to develop robust and cost-efficient means of delivering that monitoring scheme. This comment is made as a general prelude to the following points which discuss more technical matters.

23. Comment: It was difficult to assess the water-quality benefits of CSF interventions in the pilot catchments; due to the relative lack of high quality baseline (pre-intervention) data and the absence of 'control' catchments with which to make comparisons.

23. Recommendation: Future CSF initiatives should pay close attention to the design of the water quality monitoring programme, to ensure that adequate pre-treatment baseline data are collected; using methods with appropriate detection limits for the type of water body under consideration. Should budgets allow, 'control' catchments should also be monitored;

so that WQ results can be analysed using appropriate statistical methods. Sampling intervals should also be appropriate to the type of water body. For example, for 'flashy' upland catchments, weekly measurements might be appropriate. Attention should also be given to the deployment of continuous monitors; especially in catchments where DO and NH_3 are contributing to diffuse pollution. For catchments where suspended sediments and P are important, event sampling should be considered alongside the routine monitoring. It may prove cost-effective to consider the use of automated chemical monitors for P and N in some catchments. When other agencies, such as the Environment Agency, are involved in collecting data which may be used as part of the project evaluation, then ensure that data are expressed in a format that is useful to the project evaluation. For example, expressing data as 'less than X' may be useful in a regulatory sense, but is not useful when monitoring real changes in water quality over time.

24. Comment: The hydrological data from the pilot catchments emphasises the variability of the British climate; exemplified by the unseasonably high rainfall during the summer of 2007. Given the strong coupling between the transport of diffuse pollutants such as suspended sediments and phosphorus and rainfall / runoff, hydrological data are key variables in evaluating the success of any CSF remedial measures for water quality. Furthermore, hydrology is one of the principal drivers in most catchment-scale water quality models; which often require closure of the water balance as a pre-requisite to simulating chemical responses.

24. Recommendation Future CSF initiatives should pay adequate attention to the provision of appropriate rainfall and flow data for the target catchments. This may require supplementary measurements, particularly in small rural headwater catchments, where coverage by national monitoring networks is likely to be poor.

25. Comment: In remote rural catchments private sewage treatment systems (PSTSs) represent a potential source of nutrients to the aquatic environment. At present the contribution from these systems has not been quantified in the Tegid and Deepford catchments. More widely, relatively little research has been undertaken to examine the water quality threat posed by PSTSs.

25. Recommendation: It would be seem wise to consider the contribution from PSTSs when planning future CSF projects, and it may be worthwhile mapping the location and condition of the PSTSs within the target catchments.

26. Comment: A number of techniques now exist for making nutrient measurements which give an indication of the diffuse pollution risk of catchment soils. Whilst the Olsen-P test is useful measure for farmers, it is less reliable as an indicator of diffuse pollution risk since it takes no account of the capacity of a soil to absorb P.

26. Recommendation: Future CSF initiatives should consider the use of analyses such as the DESPRAL soil test or estimates of EPC_0.

Project evaluation

27. Comment: It is excellent that evaluation of this project was planned from the beginning of the project, but it would be useful if the timescale for completing the evaluation could be longer than the project lifetime. This would allow more complete evaluation of the project data at the time of completion; and it would also enable monitoring of environmental outcomes (here, water quality) to be continued for some time. In reality, some of the capital works in the CSF project may only have been completed a few weeks before the end of the project; and it is therefore unlikely that these developments would have any impact on the environment during the project's lifetime.

27. Recommendation: Plan the evaluation from the outset of the project, but ensure that some level of evaluation can continue for an appropriate time after the public project end date.

28. Comment: Farmers gave substantial amounts of their time to answering interview questions during the evaluation process. Although there were very few objections to participating in these evaluation activities, farmers greatly appreciated the £25 payment offered in recompense for the inconvenience of being interviewed. It gave a clear signal that their time was valued by the project, and this really helped develop good relations between the evaluation staff and the farmers.

28. Recommendation: Try and maintain some level of recompense for farmers who participate in surveys.

Overall comments and evaluation

Given the changes that have occurred in the allocation of financial support to farmers over the last 20 years, this project, which sought to provide support for capital improvements on farm, was innovative and daring. It tackled a real problem of under-investment on farms and has helped farmers reduce the risk of pollution.

The project was well received by farmers. Although there was some initial concern, the opinions of many farmers changed during the course of the project; becoming much more positive about the scheme in general and its overall aims. The allocation of dedicated project staff and the development of personal relations with the farmers was a major contributory factor in its success.

Inevitably, due to the source of funding there were some constraints on the project. It is very difficult to bring about change in a catchment over two years, and simultaneously measure and monitor the effects of that change on the environment. If similar projects were to be completed elsewhere, it would be beneficial to fund specific monitoring activities of environmental outputs. These should include good baseline data; and continue beyond the end of the project. Only if such baseline data are available can the economic efficiency of the project be measured.

When allocating budgets in projects like this, it is tempting to offer as much money as possible to the final beneficiaries (here, the farmers); and to minimize administrative and management costs. However, farmers do not behave like financially rational automata when considering the adoption of voluntary schemes like this. Rather, the 'softer' social aspects of adoption are very important in determining take-up: self esteem; status and role in the community; feelings of stewardship; desire to reflect a positive image of farmers and farming. It is therefore essential that sufficient consideration and resources are allocated to activities that enhance adoption (i.e. in addition to the standard financial incentives).

These activities are particularly important in a scheme like CSF, which seeks to affect water quality. This is because we would not expect a simple linear relationship between the amount of land in the scheme and improvements in water quality. Rather, because of their location in the catchment, some farms inevitably have the potential to pollute rivers more

than others. For this reason, we may expect overall water quality in the catchment to increase most markedly when these 'high risk' farms are involved in any pollution reduction scheme. Further reductions in risk will occur as more farms enter the scheme, and maximum benefits will occur when all farms in the catchment enter the scheme. However, the exact form of the relationship between the number of farms in the scheme and reduction in pollution risk is not known; and may be best investigated through the use of catchment-scale simulation models.

Given what we know about farmer behaviour, it is unlikely that maximum adoption will occur if a 'hands-off' approach to scheme participation is adopted, in which farmers are simply offered a financial incentive to adopt the scheme. Rather, CSF-type agri-environment schemes may require greater interpersonal contact than other types of agri-environment scheme which can be administered more remotely. Indeed, it could be argued that the higher the pollution risk a particular farm poses, the greater should be the time that project officers spend interacting with that farmer; as generally the higher the level of social interaction, the greater will be the chance of adoption.

Achieving high levels of social interaction requires high officer-to-farmer ratios; and in many ways the high ratio of officers-to-farmers observed in the CSF pilot study was the main reason for its success. Hiring suitable numbers of appropriate staff can be costly; and farmers can be critical of what they consider to be high administrative costs. However, the overall success of the project can only be judged by comparing costs and benefits. If levels of adoption are improved by high officer-to-farmer ratios, and if in particular the chance of getting high risk farms to adopt the scheme are increased by high officer-to-farmer ratios, then the benefits flowing from the higher administrative costs may be justified. A contrary argument is that we cannot know whether or not lower officer-to-farmer ratios would have had any impact on adoption in the CSF pilot schemes, and it is possible that some costs could have been removed from the project without reducing benefits. These are the sorts of questions that can be more easily explored with the help of suitable catchment-level models, and it may be worthwhile engaging in such an exercise prior to designing a further set of catchment-sensitive farming schemes.